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MICHIGAN
GEOLOGICAL AND BIOLOGICAL
SURVEY
BIENNIAL REPORT OF THE DIRECTOR
1912-1914

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MICHIGAN GEOLOGICAL AND BIOLOGICAL SURVEY.

Publication 17.

Geological Series 14.

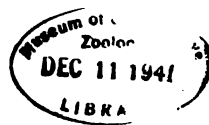
BIENNIAL REPORT OF THE DIRECTOR



PUBLISHED AS A PART OF THE ANNUAL REPORT OF THE BOARD OF
GEOLOGICAL AND BIOLOGICAL SURVEY FOR 1914.

LANSING, MICHIGAN
WYNKOOP HALLENBECK CRAWFORD CO., STATE PRINTERS
1914
24

51,724



BOARD OF GEOLOGICAL AND BIOLOGICAL SURVEY, 1914.

EX OFFICIO:

THE GOVERNOR OF THE STATE,

HON. WOODBRIDGE N. FERRIS.

THE SUPERINTENDENT OF PUBLIC INSTRUCTION,

HON. FRED L. KEELER.

THE PRESIDENT OF THE STATE BOARD OF EDUCATION,

HON. WM. J. MCKONE.

DIRECTOR,

R. C. ALLEN.

SCIENTIFIC ADVISORS.

Geologists.—Dr. L. L. Hubbard, Houghton; Prof. W. H. Hobbs, Ann Arbor; Prof. W. H. Sherzer, Ypsilanti.

Botanists.—Prof. E. A. Bessey, East Lansing; Prof. F. C. Newcombe, Ann Arbor.

Zoologists.—Prof. W. B. Barrows, East Lansing; Prof. J. Reighard, Ann Arbor; Dr. Bryant Walker, Detroit.

LETTER OF TRANSMITTAL.

*To the Honorable, the Board of Geological and Biological Survey
of the State of Michigan:*

Gov. Woodbridge N. Ferris.

Hon. Fred L. Keeler.

Hon. Wm. J. McKone.

Gentlemen:—I have the honor to transmit herewith an administrative report for the biennium ending June 30th, 1914, with the recommendation that it be printed and bound as Publication 17, Geological Series 14.

Very respectfully,

R. C. ALLEN,

Director.

Lansing, Michigan,
November 23, 1914.

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ORGANIZATION OF THE GEOLOGICAL AND BIOLOGICAL SURVEY.

The Board of Geological Survey was created in 1869 for the purpose of making a thorough *geological* and *mineralogical* survey of the state. In 1905 the Board was authorized and directed to make "a thorough *biological* survey of the state" and to engage with the federal government in a co-operative topographic survey of Michigan. In 1911 the duties which prior had devolved on a Commissioner of Mineral Statistics were transferred to the Board of Geological Survey, and in 1913 co-operative relations were established with the Board of State Tax Commissioners for the appraisal of mines and mineral lands for taxation.

The present organization of the Survey embraces three departments, viz.:

(1) The Geological Survey, including three separate divisions, which are

- (a) Division of Geology,
- (b) Division of Appraisals,
- (c) Division of Mineral Statistics.

(2) The Topographic Survey.

(3) The Biological Survey.

EXPENDITURES.

The act of 1869 provides a fund of \$8,000.00 per annum for the Geological Survey, but since 1905 this has been augmented by additional funds, through biennial appropriations by the legislature, necessary for progress with the topographic and biologic surveys and for the discharge of co-operative work with the Board of State Tax Commissioners. The total of appropriations for all purposes, for the fiscal year ending June 30, 1913, was \$11,000.00, and for the fiscal year ending June 30, 1914, \$20,500.00. I submit below classified accounts of expenditures for the biennium showing (1) the actual cost of the various activities and investigations and (2)

a classified list of expenditures, as shown on vouchers paid by the State Treasurer from the continuing or general appropriation and by the Treasurer of the Board of Geological Survey from the special appropriations. I present also the names of the persons employed by the Board of Geological Survey during the biennium, the capacities and length of time in which such persons were employed and total salary received.

EXPENDITURES OF THE BOARD OF GEOLOGICAL SURVEY.
1912-1913 and 1913-1914. (Fiscal years ending June 30th.)

Work.	Total.	Salary.	Subsistence.	Travel.	Assistance.	Property.	Office.	
							Permanent.	Incidental.
Appraisal of mines, 1913-14.....	\$8,059 86	\$6,668 70	\$492 17	\$285 68	.....	\$26 03	\$50 66	\$536 62
Topographic survey, 1912-13 and 1913-14.....	4,044 93	1,788 08	1,477 86	539 01	.....	240 48	.....	9 50
General and miscellaneous office and correspondence work, 1912-13 and 1913-14.....	3,929 95	3,343 92	.....	.....	\$12 00	199 07	40 00	334 96
Watersmeet-Marengo-Gogebic field work, 1912-13.....	2,838 47	2,052 83	313 96	137 70	35 55	184 07	14 34	100 02
Biological Survey, 1912-13 and 1913-14.....	2,057 30	2,000 00	.....	.....	.....	.....	.....	57 30
Oil and gas report, 1912-13 and 1913-1914.....	1,586 29	1,346 57	22 90	15 04	20 17	50 45	34 75	96 41
Mineral statistics, 1912-13 and 1913-14.....	1,395 64	1,244 23	22 90	23 47	.....	.....	27 06	99 98
Study of Copper Deposits, 1912-1913 & 1913-1914.....	1,089 12	960 00	21 85	74 29	.....	.....	9 50	23 78
Physiography of Michigan Inland Lakes, 1913-14.....	1,873 75	569 35	9 65	229 66	.....	54 59	.....	10 50
Delta County, Little Lake and Gwin District Survey, 1913-14.....	838 67	466 15	235 88	66 59	13 10	25 13	.....	31 82
Petrographic Studies—Iron Ranges and associated rocks S. and E. of Gogebic Range, 1913-14.....	816 48	711 44	.....	.....	.....	40 93	18 76	45 35
Copper statistics and progress of Copper Industry, 1912-13 and 1913-14.....	727 15	659 49	3 95	21 61	.....	.....	10 50	31 60
Study of Limestones, 1913-14.....	677 49	336 00	65 30	67 26	97 62	67 90	15 67	27 74
Report on Limestone Mountain, 1913-14.....	343 84	200 00	32 30	96 36	4 20	.....	.....	10 98
General laboratory work, 1912-13 and 1913-14.....	291 34	210 53	.....	.....	.....	9 55	21 24	50 02
Traverse-Dundee report, 1912-1913 and 1913-14.....	259 63	205 73	.....	36 77	9 23	34 52	14 33	53 90
Re-survey east end of Gogebic Range, 1913-14.....	228 94	31 79	56 20	.....	10 50	.....	.....	46 10
Moving equipment from Houghton to Lansing, 1912-13.....	161 12	46 57	13 25	86 78	.....	.....	.....	4 02
Gasco reading on Escanaba River, 1912-13 and 1913-14.....	108 00	108 00	.....	.....	.....	.....	.....	.....
Report on salt; balance due, 1913-14.....	82 07	62 07	.....	.....	.....	.....	.....	.....
Total.....	\$30,390 04	\$23,001 45	\$2,746 17	\$1,680 22	\$202 37	\$932 72	\$256 81	\$1,570 30
July 1, 1914:								
Unexpended balance, general appropriation.....	333 69							
Unexpended balance, topography.....	776 92							
Total.....	\$31,500 65							

BIENNIAL REPORT OF THE DIRECTOR.

CLASSIFIED LIST OF EXPENDITURES OF THE BOARD OF GEOLOGICAL SURVEY FOR THE FISCAL YEARS 1912-1913 AND 1913-1914. (Continued).

Numbers of vouchers.	Name.	Classification.	Total.	Salary.	Subsistence.	Travel.	Assistance.	Property.	Office.	
									Perma- nent.	Inciden- tal.
63.	Adder Machine Co.	Supply house.	\$339 50	\$42 00	\$1 65	\$8 32		\$339 50		
29, 30.	Allen, H. J.	Geologist.	51 97							
1, 8, 36, 56, 75, 87, 101, 119, 136, 152, 163, 174, 183, 1, 3, 5, 6, 8, 18, 33, 73, 36, 37, 90, 45, 47, 50, 51, 114, 132, 145, 163, 63, 72, 149, 7, 35, 71, 86, 100, 111, 118, 131, 149, 29, 36, 48, 89, 112, 126, 138, 179, 84.	Allen, R. C.	Director & State Geologist	5,539 69	4,910 37	251 71	254 20	\$7 00	4 25		\$112 16
67, 78, 95, 112, 133, 147, 162, 171, 181, 34, 62, 72, 97, 111, 131, 132, 143, 162.	Allen Printing Co.	Supply house.	75 31		1 25	4 20		12 05	\$2 93	60 33
43.	Alverson, Miles C.	Compassman.	5 45							
72, 99, 144, 71, 168.	American Express Co.	Transportation Co.	127 10							127 10
13, 29, 31, 22, 33, 36, 39, 40, 45, 47, 117, 136, 146, 166, 63, 68, 77, 49, 93, 145, 178, 49, 86, 140, 174.	Andrews, A. W.	Biologist.	50 00	50 00						29 15
104.	Auditors, Board of.	Supply house.	29 15							70
218, 219, 241, 242, 253, 254.	Barrett, L. P.	Assistant Geologist.	980 71	812 90	84 43	77 93		4 75		
66.	Beauchamp, Olive & Regis	Gage readers.	108 00	108 00						
290.	Berthoud, Mary L.	Copyist.	45 60		161 00	78 45	45 60			
17, 77, 43.	Bibbes, E. C.	Topographic assistant.	479 45	240 00						
52.	Bibliotheca Co.	Publishers.	5 25						5 25	
120.	Blunt, H. M.	Liverman.	10 00			10 00				13 67
206, 207, 216.	Bovee, F. N.	Photographer.	13 67							
70.	Bryan, Katherine	Copyist.	5 00	5 00						
24, 25, 61.	Buck, M. J. & B. M.	Supply house.	30 00					30 00		
45, 106.	Busan, Walter	Roomman.	90 48	39 99	50 50					
33, 31.	Carlson Supply Co.	Supply house.	17 75	100 00	10 20	33 51				17 75
5, 69, 146, 159, 27, 56, 102, 155.	Case, E. C.	Geologist.	143 71							
189, 98.	Chicago University of	Publishers.	8 00						8 00	
253, 256, 266, 267, 269, 270.	Chilton-McKinley Co.	Directory publishers.	10 00					10 00		
	Clatsop Telephone Co.	Telephone Co.	78 25							78 25
	Clear-Bauer Co.	Drayage company.	7 01							7 01
	Chute, R. G.	Junior topographer.	312 36	104 52	117 25	30 49				

BIENNIAL REPORT OF THE DIRECTOR.

177.	Columbia Carbon Co.	Supply house.	2 00																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
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CLASSIFIED LIST OF EXPENDITURES OF THE BOARD OF GEOLOGICAL SURVEY FOR THE FISCAL YEARS 1912-1913 AND 1913-1914. (Continued)

Numbers of vouchers.	Name.	Classification.	Total.	Salary.	Subsistence.	Travel.	Assistance.	Property.	Office.	
									Perma- nent.	Inciden- tal.
113, 91.....	Iron Trade Review.....	Publishers.....	\$8 00						\$4 00	\$4 00
206, 207, 216.....	Kaster, E. G.....	Rodman.....	90 40	\$39 99	\$50 50					
76, 81.....	Kelly Brothers.....	Supply store.....	30 50		30 50					
40, 41, 65.....	Kelly, J. L.....	Supply store.....	137 81		137 81					
194.....	Kelly, T.....	Liveryman.....	14 00			\$14 00				
197.....	Lee, L. L.....	Assistant topographer.....	167 00	125 00	42 00					
63.....	Links, G. P.....	Compassman.....	36 00	36 00						
16, 23, 27, 28.....	Ludington Hotel.....	Hotel.....	125 50		125 50					
18.....	Luther, Geo. B.....	Rodman.....	45 33	19 83	25 50					
19, 26, 44.....	McElwain, J. Millard.....	Compassman.....	120 00	118 00	2 00					
94, 130.....	McGraw-Hill Book Co.....	Publishers.....	7 13						7 13	
71.....	McKinn, Don T.....	Compassman.....	15 41		2 50	12 91				
15.....	Marshall, E. E.....	Copyist.....	10 45	10 45						
68.....	Mead Storage Co.....	Drayage company.....	11 00							11 00
69.....	Mich. Central R. R. Co.....	Transportation company.....	74 40							74 40
30, 83, 128, 130, 142, 170, 179, 13, 14, 23, 74, 87, 88, 124.....	Michigan Drug Co.....	Supply house.....	117 03					\$102 25		14 75
32.....	Mich. Engineering Society.....	Publishers.....	4 00							4 00
92.....	Mich. Press Clip g Bureau.....	News bureau.....	4 00						4 00	
6, 94, 110, 160, 13, 57, 104, 157, 170, 175.....	Michigan Telephone Co.....	Telephone company.....	80 55							80 55
46.....	Michigan, University of.....	Educational institution.....	93 37				\$93 37			
32, 169.....	Mining Gazette.....	Publishers.....	4 00							4 00
115.....	Mining Journal Co.....	Publishers.....	2 00							2 00
180.....	Mining World.....	Publishers.....	3 00							3 00
81.....	Montgomery Ward & Co.....	Supply house.....	0 15					6 15		
186, 193.....	Mull, Ira D.....	Liveryman.....	66 00			66 00				
16.....	Munson Supply Co.....	Supply house.....	6 30					6 30		
94.....	Newcombe, F. C.....	Member Bd. of Advisers.....	3 33		75	2 58				
44.....	Osia, C. H.....	Biologist.....	25 00	25 00						
137, 159.....	Proudt Loose Leaf Co.....	Supply house.....	9 92					9 92		
12, 13, 66.....	Raymond, E. B.....	Cook.....	166 20	160 00	5 00	1 20				

BIENNIAL REPORT OF THE DIRECTOR.

[illegible]

CLASSIFIED LIST OF EXPENDITURES OF THE BOARD OF GEOLOGICAL SURVEY FOR THE FISCAL YEARS 1912-1913 AND 1913-1914. (Continued).

Numbers of vouchers.	Name.	Classification.	Total.	Salary.	Subsistence.	Travel.	Assistance.	Property.	Office.	
									Permanent.	Incidental.
206, 207, 208, 216, 217 172, 177 74, 132, 176, 180 206, 207, 217 21, 24, 46	Wilson, J. H. Wood, N. A. Wyndp Hallen's Cr'd Co Yakum, B. H. Young, L. J.	Junior topographer Biologist State printers Recorder Field assistant	\$219 47 250 00 18 80 68 49 116 78	\$95 00 250 00 44 99 116 00	\$62 00 50 50	\$62 47 78				\$18 80
Total			\$30,390 04	\$23,001 45	\$3,746 17	\$1,680 22	\$202 37	\$932 72	\$256 81	\$1,570 30
Unexpended balance July 1, 1914			1,110 61							
Total			\$31,500 65							

EMPLOYEES OF THE BOARD OF GEOLOGICAL SURVEY FOR THE FISCAL YEARS, JULY 1, 1912 TO JUNE 30, 1913 AND JULY 1, 1913 TO JUNE 30, 1914.

Name.	Position.	Amount of salary received.	Period of time employed.	How employed.				
				Geology.	Appraisal of mines.	Topography.	Biology.	Mineral statistics.
Allen, R. C.	Director and State Geologist.	\$4,910 37	1 year, 11 months, 16½ days.	*	*	*	*	*
Allen, H. J.	Geologist.	42 00	12 days.	*				
Andrews, A. W.	Biologist.	50 00	Contract.				*	
Barrett, L. P.	Assistant Geologist.	812 90	10 months, 26 days.					
Beauchamp, Olive & Regis.	Gage Readers.	108 00	2 years.	*				
Bibbee, E. C.	Topographic Assistant.	240 00	3 months.			*		
Bryan, Katherine.	Copyist.	5 00	2 days.					*
Rudan, Katherine.	Copyist.	39 99	31 days.			*		
Rudan, Walter.	Geologist.	100 00	Contract.	*		*		
Case, E. C.	Junior Topographer.	164 52	2 months, 7 days.					
Clinite, R. G.	Geologist.	62 07	Contract.	*				
Cook, C. W.	Compassman.	112 67	3 months, 2 days.	*				
Cortess, Geo. B.	Geologist.	35 00	7 days.	*				
Crane, Guy W.	Draftsman.	922 94	1 year, 10 days.	*				
Dennis, J. H.	Compassman.	40 65	1 month, 5 days.	*				
Dick, Raymond.	Compassman.	450 00	4 months.	*			*	
Dodge, C. K.	Compassman.	136 00	3 months, 3 days.	*		*		
Kellows, Bert.	Rodman.	73 50	2 months.	*				
Freeman, Leon.	Stenographer.	707 66	1 year, 4 months, 6 days.	*	*			*
Fruitt, Pearl A.	Paleontologist.	100 00	Contract.	*				
Graham, A. W.	Rodman.	128 65	3 months, 7 days.	*		*		
Graves, J. T.	Mining Engineer.	2,100 00	1 year.	*	*	*		*
Hamilton, O. R.	Compassman and Rodman.	202 23	6 months, 6 days.	*		*		*
Havens, R. B.	Geologist.	62 50	3 months.	*				*
Hopper, W. E.	Geologist.	1,435 00	1 year, 6 months, and contract.	*				*
Hore, R. E.	Geologist.			*				*

EMPLOYEES OF THE BOARD OF GEOLOGICAL SURVEY FOR THE FISCAL YEARS, JULY 1, 1912 TO JUNE 30, 1913 AND JULY 1, 1913 TO JUNE 30, 1914.—*Concluded.*

Name.	Position.	Amount of salary received.	Period of time employed.	How employed.				
				Geology.	Appraisal of mines.	Topography.	Biology.	Mineral statistics.
Hus, H.	Biologist.	\$25 00	Contract.					
Kaster, E. G.	Rodman.	39 99	31 days.			*	*	
Lee, L. L.	Assistant Topographer.	125 00	1 month.			*		
Links, G. P.	Compassman.	36 00	27 days.	*				
Luther, Geo. B.	Rodman.	19 83	17 days.			*		
McElwain, J. Millard.	Compassman.	118 00	3 months.	*				
Marshall, E. E.	Copyist.	10 45	4 days, 1 hour, 15 minutes.					*
Otis, C. H.	Biologist.	25 00	Contract.				*	
Raymond, E. B.	Cook.	160 00	2 months, 4 days.	*				
Richmond, Mrs. K. V.	Stenographer.	452 50	7 months.	*	*			*
Robinson, W. I.	Geologist.	100 00	1 month.	*				
Ruthven, A. G.	Chief Naturalist.	800 00	2 years.	*			*	
Scott, I. D.	Geologist.	569 35	2 months and contract.					
Seymour, K. D.	Rodman.	39 99	31 days.			*		
Small, T. L.	Rodman.	77 98	1 month, 29 days.			*		
Smith, R. A.	Geologist.	2,759 93	2 years.	*	*	*		*
Thompson, Crystal.	Biologist.	150 00	2 months.				*	
Thompson, Helen B.	Biologist.	250 00	2 months and contract.				*	
Townsend, L. D.	Junior Topographer.	281 29	3 months, 16 days.	*	*	*		
Vance, E. E.	Draftsman.	1,200 00	1 year.					
Wight, Harry R.	Secretary.	2,200 00	2 years.	*	*	*	*	*
Wilson, J. H.	Junior Topographer.	95 00	1 month.			*		
Wood, N. A.	Biologist.	230 00	2 months.			*	*	
Yakum, B. H.	Recorder.	44 99	31 days.			*		
Youngs, L. J.	Field Assistant.	116 00	3 months.	*		*		

POWERS AND DUTIES OF THE BOARD OF GEOLOGICAL SURVEY.

The powers and duties of the Board of Geological Survey in reference to the geological survey of the state are defined in act number sixty-five of the laws of 1869, as follows:

AN ACT to provide for the further Geological Survey of the State.

Section 1. *The People of the State of Michigan enact*, That the governor, superintendent of public instruction, and the president of the state board of education shall constitute a board of geological survey. They shall control and supervise the continuance and completion of the geological survey of the state; and for that purpose they may from time to time appoint such person or persons to assist in making said survey as may be deemed necessary; the length of time, and the location and locations where said persons shall be employed, shall be determined by said board.

Sec. 2. Repealed by the amendatory act of 1871.

Sec. 3. The salary of the persons employed in the survey shall be fixed by the board, and shall be payable only for services actually rendered. Such board shall regulate all expenses incident to the survey, and may require such frequent reports as they may think useful.

Sec. 4. It shall be the duty of said board to make, or cause to be made, a thorough geological and mineralogical survey of the state, embracing a determination of the succession and arrangement, thickness, and position of all strata and rocks, their mineral character and contents, and their economical uses; an investigation of soils and subsoils, and the determination of their character and agricultural adaption; the investigation of all deposits of brines, coal, marl, clay, lime, gypsum, petroleum, and metals and metallic ores, building stone, marble, grit stone, materials for mortar and cement, mineral paint, and all other productions of the geological world within the limits of this state, capable of being converted to the uses of man.

Sec. 5. It shall be the duty of said board to cause ample materials to be collected for the illustrations of every department of the geology and mineralogy of the state, and to label, arrange and prepare the same for exhibition in suitable cases in the museums of the state university, agricultural college, and state normal school, and in each of the incorporated colleges of the state, and in a room in connection with the state library.

Sec. 6. It shall be the duty of said board to furnish an annual report of the progress of the survey, and as often as possible a condensed statement of important and interesting facts for general circulation; and as soon as the progress of the work will permit, to begin, and, on the completion of the survey, to furnish (finish) a complete memoir upon the geology of the state, embracing such an account of all its mineral and agricultural resources as is usual in works of that character, and a delineation of its geology on the map of the state, and such other diagrams and illustrations as may be needed to set forth in a creditable, intelligible, and, as far as possible, popular manner, the nature, location, and extent of the geological and agricultural resources of the state: Provided, That said report shall not contain in any considerable extent compilations and extracts of or from books heretofore published.

Sec. 7. Repealed by the amendatory act of 1871.

Sec. 8. All notes, memoranda, compilations, collections, specimens, diagrams, and illustrations that may be made in the progress of such sur-

vey, by the person or persons engaged therein, shall be the property of the state, shall be under the control of the board, and, in the case of the death or termination of connection with such survey of any such person or persons, shall be deposited in the office of the superintendent of public instruction, subject to the order of the board.

Sec. 9. To carry into effect the provisions of this act, the sum of eight thousand dollars for each year, until the completion of said survey is hereby appropriated to be drawn from the treasury as needed. The accounts of the members of the board for official services and all other expenses authorized by law shall first be certified to be correct by said board, and shall be paid out of the state treasury upon the warrant of the auditor general from the fund appropriated for that purpose: Provided, No part of said appropriation shall be used for printing reports.

FUNCTIONS OF THE GEOLOGICAL SURVEY.

The work of the Geological Survey consists not only in the acquisition and publication of information concerning the geology, soils and mineral resources of Michigan, but also in making such information effective in developing and conserving the natural resources and in aiding in the administration of the laws bearing upon the exploitation, conservation, taxation, etc., of these resources.

The results of the work of the Survey are made available through, (1) the distribution of its publications to libraries, educational and scientific institutions, the press, and individuals who have proper use for them, (2) through correspondence and conferences in the field and in the office, and (3) through co-operation with other departments of the government, viz., the Public Domain Commission, Michigan Securities Commission, and the Board of State Tax Commissioners.

DISTRIBUTION OF THE REPORTS OF THE BOARD OF GEOLOGICAL SURVEY.

It is difficult to estimate the importance of the dissemination of information in the form of printed reports to public libraries and the libraries of educational and scientific institutions, but by reference to other sources of demand for these reports it is apparent that they are being widely and intelligently used in the development of the natural resources of the state.

The editions of the reports of the Board of Geological Survey are limited by law to not more than 1,500 copies. For most of the publications this edition is not large enough to supply the demand and it is therefore very important that the utmost care be exercised in distribution. Several of the important reports are out of stock

and no longer available except through second-hand book dealers, usually at advanced prices.

In considering the matter of the wisest distribution of the publications it has been decided that the claims of public libraries must take precedence over individuals and other organizations, and Michigan libraries over those in other states and countries. The needs of scientific and educational institutions must next be met, and from what remains of the editions individuals may be supplied. It has been the custom to honor requests for reports from Michigan citizens *gratis* on receipt of forwarding charges and on proper representation that the same are to serve a useful purpose, but individuals outside the state are required to pay both cost and transportation. When the stock of any report is reduced to one hundred copies the price is advanced and must be paid by all alike including libraries, organizations and individuals whether in or out of the state. All moneys received from sale of reports are turned over to the State Treasurer and credited by him to the general fund.

Through a system of exchanges with scientific organizations in this and foreign countries a steadily growing library is being acquired. On November 5, 1914, the library contained 4,069 titles. It is mainly used by the employees of the Board of Geological Survey, but is also available for the use of the general public.

Below are listed the libraries, scientific and educational institutions to which the reports of the Survey are delivered in the order in which they are issued. Those from which publications are received in exchange are indicated on the list by an asterisk.

MICHIGAN PUBLIC LIBRARIES, SCIENTIFIC AND EDUCATIONAL INSTITUTIONS.

Name.	Address.
Adrian College	Adrian, Michigan.
Albion College	Albion, Michigan.
Alma College	Alma, Michigan.
Ann Arbor Public Library	Ann Arbor, Michigan.
*University of Michigan Library.....	Ann Arbor, Michigan.
Benton Harbor College	Benton Harbor, Michigan.
Benzonia Academy	Benzonia, Michigan.
Ferris Institute	Big Rapids, Michigan.
Detroit College	Detroit, Michigan.
Detroit Seminary	Detroit, Michigan.
*Michigan Agricultural College	East Lansing, Michigan.
Hillsdale College	Hillsdale, Michigan.
Hope College	Holland, Michigan.
*College of Mines	Houghton, Michigan.
Western State Normal College.....	Kalamazoo, Michigan.

Name.	Address.
Northern State Normal College	Marquette, Michigan.
Central State Normal College	Mt. Pleasant, Michigan.
*Olivet College	Olivet, Michigan.
Cleary's Business College	Ypsilanti, Michigan.
State Normal College	Ypsilanti, Michigan.
Adrian Public Library	Adrian, Michigan.
Albion Public Library	Albion, Michigan.
Township Library	Allegan, Michigan.
Public Library	Alpena, Michigan.
Armada Free Public Library	Armada, Michigan.
Battle Creek Public School Library	Battle Creek, Michigan.
Bay City Public Library	Bay City, Michigan.
The Phelps Free Library	Big Rapids, Michigan.
City Library	Benton Harbor, Michigan.
Bessemer Public Library	Bessemer, Michigan.
Cadillac Public Library	Cadillac, Michigan.
Calumet and Hecla Company Library	Calumet, Michigan.
Free Public Library	Charlotte, Michigan.
Public Library	Detroit, Michigan.
A. J. Phillips Library	Fenton, Michigan.
Public School Library	Frankfort, Michigan.
Grand Haven Public Library	Grand Haven, Michigan.
Grand Ledge Public Library	Grand Ledge, Michigan.
Grand Rapids Public Library	Grand Rapids, Michigan.
Central High School Library	Grand Rapids, Michigan.
Kent Scientific Museum	Grand Rapids, Michigan.
Public School Library	Hancock, Michigan.
Harbor Springs Public Library	Harbor Springs, Michigan.
Houghton Public Library	Houghton, Michigan.
Howell Carnegie Library	Howell, Michigan.
Hudson Public Library	Hudson, Michigan.
Carnegie Library	Ironwood, Michigan.
Jackson Public Library	Jackson, Michigan.
Ladies Library	Jonesville, Michigan.
Public Library	Kalamazoo, Michigan.
Kalamazoo College Library	Kalamazoo, Michigan.
*Lansing Public Library	Lansing, Michigan.
Ludington Public Library	Ludington, Michigan.
Marine City Public School Library	Marine City, Michigan.
Peter White Public Library	Marquette, Michigan.
Mendon Free Public Library	Mendon, Michigan.
Mt. Pleasant Public Library	Mt. Pleasant, Michigan.
Spies Public Library	Menominee, Michigan.
Hackley Public Library	Muskegon, Michigan.
Public Library	Niles, Michigan.
Ladies Library	Northville, Michigan.
Otsego Public School Library	Otsego, Michigan.
Township Library	Otsego, Michigan.
Public Library	Petoskey, Michigan.
Port Huron Public Library	Port Huron, Michigan.
Quincy Free Public Library	Quincy, Michigan.
Romeo Public Library	Romeo, Michigan.
Dunbar School of Agriculture	Sault Ste. Marie, Michigan.
Hoyt Library	Saginaw, Michigan.
Saginaw (E. S.) Public School Libr.	Saginaw, Michigan.
Saranac Public School Library	Saranac, Michigan.
Traverse City Public Library	Traverse City, Michigan.
Tecumseh Public Library	Tecumseh, Michigan.
Three Rivers Free Library	Three River, Michigan.
Township Library	Union City, Michigan.
Schoolcraft Township Library	Vicksburg, Michigan.
*State Highway Department	Lansing, Michigan.

FOREIGN COLLEGES, LIBRARIES, SCIENTIFIC AND EDUCATIONAL INSTITUTIONS.

Name.	Address.
University of Arizona Library.....	Tucson, Arizona.
McGill University Library	Montreal, Canada.
Manitoba University Library	Winnipeg, Canada.
*Colorado School of Mines Library.....	Golden, Colorado.
Sheffield Scientific School, Dept. of Geology	New Haven, Connecticut.
*University of Chicago	Chicago, Illinois.
*Field Museum of Natural History.....	Chicago, Illinois.
John Crerar Library	Chicago, Illinois.
*University of Illinois Library.....	Urbana, Illinois.
*Purdue University Library	LaFayette, Indiana.
Northern Ind. Historical Society.....	South Bend, Indiana.
Howard Memorial Library	New Orleans, Louisiana.
Amherst College Library.....	Amherst, Massachusetts.
Mass. Institute of Technology.....	Boston, Massachusetts.
Williams College Library	Williamston, Massachusetts.
University of Minn., Winchell Library of Geology	Minneapolis, Minnesota.
*Minnesota Historical Society	St. Paul, Minnesota.
University of Missouri Library.....	Columbia, Missouri.
*University of Missouri, (School of Mines and Metallurgy).....	Rolla, Missouri.
St. Louis Public Library	St. Louis, Missouri.
Rutgers College Library	New Brunswick, New Jersey.
Princeton University Library	Princeton, New Jersey.
Grosvenor Public Library	Buffalo, New York.
Cornell University Library	Ithaca, New York.
American Society of Civil Engineers..	New York City, New York.
American Geographical Soc. of N. Y....	New York City, New York.
*American Museum of Natural History..	New York City, New York.
New York Public Library	New York City, New York.
New York Univ., Dept. of Geology.....	New York City, New York.
Public Library of Cincinnati	Cincinnati, Ohio.
Adelbert College Library	Cleveland, Ohio.
Cleveland Public Library	Cleveland, Ohio.
Ohio State University Library	Columbus, Ohio.
Oberlin College Library	Oberlin, Ohio.
*State University of Oklahoma, Dept. of Geology	Norman, Oklahoma.
Muhlenberg College	Allentown, Pennsylvania.
Bryn Mawr College Library	Bryn Mawr, Pennsylvania.
Pennsylvania State Museum	Harrisburg, Pennsylvania.
Academy of Natural Sciences	Philadelphia, Pennsylvania.
American Philosophical Society.....	Philadelphia, Pennsylvania.
University of Pennsylvania	Philadelphia, Pennsylvania.
Free Library of Philadelphia	Philadelphia, Pennsylvania.
*Carnegie Library	Pittsburgh, Pennsylvania.
Lehigh University, Dept. of Geology..	South Bethlehem, Pennsylvania.
Fisk University, Geological Library...	Nashville, Tennessee.
Seattle Public Library	Seattle, Washington.
Milwaukee Public Library	Milwaukee, Wisconsin.
Milwaukee Public Museum	Milwaukee, Wisconsin.
*Chicago Academy of Science	Chicago, Illinois.
*Davenport Academy of Science	Davenport, Iowa.
*Colorado College	Colorado Springs, Colorado.
*Kansas Academy of Science	Topeka, Kansas.
*Portland Society of Natural History...	Portland, Maine.

Name.	Address.
Boston Society of Natural History.....	Boston, Massachusetts.
*Geological Museum	Cambridge, Massachusetts.
*University of Minnesota	Minneapolis, Minnesota.
Academy of Science	St. Louis, Missouri.
*Missouri Botanical Garden.....	St. Louis, Missouri.
*State Engineer and Surveyor	Albany, New York.
American Institute of Mining Engrs....	New York City, New York.
*State Bureau of Mines	Corvallis, Oregon.
Wyoming His. and Geological Society..	Wilkes-Barre, Pennsylvania.
American Mining Congress	Washington, D. C.
*Bureau of Mines	Washington, D. C.
*Department of Agriculture	Washington, D. C.
*Director of the Census	Washington, D. C.
Hygienic Laboratory	Washington, D. C.
*Library of Congress	Washington, D. C.
*Office of Public Roads, U. S. Dept. of Agriculture	Washington, D. C.
Smithsonian Institution	Washington, D. C.
*United States Geological Survey.....	Washington, D. C.
*University of Wisconsin	Madison, Wisconsin.
*Australian Museum	Sydney, Australia.
*Mines Department	Melbourne, Victoria, Australia.
*Queensland Museum	Brisbane, Australia.
*Abhandlungen Der. K. K. Geologischen Reichsanstalt	Wien, Vienna, Austria.
*Bureau of Mines	Toronto, Canada.
*Department of Mines	Ottawa, Canada.
*Geological Survey Library.....	Ottawa, Canada.
Liverpool Geological Society	Liverpool, England.
Geological Survey of Eng. and Wales..	London, England.
Patent Office Library	London, W. C., England.
*Mysore Geological Survey	Mysore, India.
*Tahaku Imperial University	Sendai, Japan.
*Imperial Geological Survey	Tokyo, Japan.
*Instituto Geológico de Mexico.....	Mexico City, Mexico.
*New Zealand Geological Survey	Wellington, New Zealand.
Da Escola de Minas de Ouro Preto....	Ouro Preto, Brazil, S. A.
Instituto de Geología Y Perforaciones..	Montevideo, Uruguay, S. A.
University of Upsala	Upsala, Sweden.
*Geological Survey of W. A.....	Perth, Western Australia.

STATE GEOLOGICAL SURVEYS.

Name.	Address.
*Geological Survey	University, Alabama.
Geological Survey	Tucson, Arizona.
*Geological Survey	Fayetteville, Arkansas.
*State Mineralogist	San Francisco, California.
*Geological Survey	Boulder, Colorado.
*Geological Survey	Middletown, Connecticut.
*Geological Survey	Tallahassee, Florida.
*Geological Survey	Atlanta, Georgia.
*Geological Survey	Urbana, Illinois.
*Geological Survey	Indianapolis, Indiana.
*Geological Survey	Iowa City, Iowa.
*Geological Survey	Lawrence, Kansas.
*Geological Survey	Lexington, Kentucky.
*Geological Survey	Baton Rouge, Louisiana.
State Survey Commission.....	Augusta, Maine.

Name.	Address.
*Geological Survey	Baltimore, Maryland.
*Geological Survey	Jackson, Mississippi.
*Geological Survey	Rolla, Missouri.
*Geological Survey	Lincoln, Nebraska.
*Geological Survey	Trenton, New Jersey.
*Geological Survey	Albany, New York.
*Geological Survey	Chapel Hill, North Carolina.
*Geological Survey	Grand Forks, North Dakota.
*Geological Survey	Columbus, Ohio.
*Geological Survey	Norman, Oklahoma.
*Topographic & Geologic Sur. Com.....	Beaver, Pennsylvania.
*Geological Survey	Charleston, South Carolina.
*Geological Survey	Vermillion, South Dakota.
*Geological Survey	Nashville, Tennessee.
*Geological Survey	Burlington, Vermont.
*Geological Survey	Charlottesville, Virginia.
*Geological Survey	Seattle, Washington.
*Geological Survey	Morgantown, West Virginia.
*Geological Survey	Madison, Wisconsin.
*Geological Survey	Cheyenne, Wyoming.

CORRESPONDENCE AND CONFERENCES.

The Survey has done much in bringing to the attention of the commercial world opportunities for profitable development of the natural resources and has had a considerable influence on the establishment of industries based upon utilization of the mineral products. Through its investigation and mapping of the soils it has been able to furnish reliable information of a general character which is having its effect upon the settlement of untilled good agricultural lands. It has saved to municipalities, particularly, large amounts of money in the development of public water supplies, and is saving to the people of Michigan large sums which would otherwise be spent in useless explorations for pure water, oil, gas, brine, minerals, etc., in locations where the geologic conditions are such as to make impossible the occurrence of the product sought, or to render its occurrence so extremely improbable that expenditure for exploration is not warranted. The Survey has been active in forewarning against many a visionary scheme of exploration.

It is the business of the Survey to encourage and aid legitimate development of the mineral resources and to discourage those which are either fraudulent or based on mistaken notions of the governing natural conditions. Its services are rendered *gratis*, but no competition is offered to practice of private experts. On the other hand the employment of such experts is advised in all cases where demanded by business prudence. The Survey is primarily a bureau of information. It conducts an extensive and growing correspondence in answering thousands of inquiries which are pre-

sented from sources both in and out of the state, and a considerable part of the time of some of its employees is absorbed in conferences on projects involving the application of geologic information.

CO-OPERATION WITH THE BOARD OF STATE TAX COMMISSIONERS IN THE
APPRAISAL OF MINES AND MINERAL LANDS.

About two years ago the Board of Geological Survey entered into co-operative relations with the Board of State Tax Commissioners, at the request of the latter, for the purpose of making available the most complete information regarding the mineral resources of Michigan which it is possible to bring to bear on the work of appraisal for taxation of mines and mineral lands. The results of this co-operation are fully accounted for in the current biennial report of the Board of State Tax Commissioners.

In the capacity of appraiser of mines the State Geologist has assumed a heavy and important responsibility, one, however, which a due appreciation of his obligations to the state does not allow him to seek to avoid. I need only to state here that no effort has been spared to fulfill the spirit and letter of the co-operative agreement. During the biennium there has been made two complete appraisals of iron mines and iron lands, one appraisal of coal mines and coal lands of Bay and Saginaw counties, and a preliminary investigation of the value of the copper mines. The permanent record of this work is embraced in two annual reports to the Board of State Tax Commissioners, comprising nine volumes of typewritten matter, plats, statistical tables, etc., and several communications on special subjects.

REPORTS OF THE STATE GEOLOGIST TO THE BOARD OF STATE TAX
COMMISSIONERS.

1913.

Volume 1. Contains formally executed detailed financial statements of each operating iron mine in Michigan for the five years preceding 1913. 806 pages.

Volume 2. Contains a complete mathematical record of appraisal and discussion by the appraiser of each property. 473 pages.

Volume 3. Contains complete statistical tables for reference. 89 pages.

Volume 4. Contains a classification of the iron and coal lands of Michigan. 99 pages.

1914.

Volume 1. Contains formally executed detailed financial statements of each operating iron mine in Michigan for the five years preceding 1914. 510 pages.

Volume 2. Contains, (1) a complete mathematical record of appraisal and discussion by the appraiser of each property and (2) a record of the formal action on the valuation of each property by the Board of State Tax Commissioners. 484 pages.

Volume 3. Contains statements of tonnage and value of ore in stock at the mines. 147 pages.

Volume 4. Contains complete statistical tables for reference. 37 pages.

Volume 5. Contains a revised classification of the iron lands of Michigan. 90 pages.

The State Geologist acknowledges here the efficient and indispensable aid rendered by Mr. O. R. Hamilton, mining engineer, in appraisal of iron lands and mines and Mr. R. A. Smith, geologist, in appraisal of coal lands and mines.

CO-OPERATION WITH THE MICHIGAN SECURITIES COMMISSION.

The work of the Geological Survey has been adapted from time to time in assisting the Michigan Securities Commission in the administration of the so-called "blue sky law" enacted in the 1913 session of the legislature. In this connection the State Geologist during the past year made a valuation of the properties of the Jackson Coal Company and the Wolverine Coal Company, and in addition has submitted opinions in a number of other cases presented to him.

CO-OPERATION WITH THE PUBLIC DOMAIN COMMISSION.

Co-operative relations are maintained with the Public Domain Commission and the Commissioner of Immigration. The State Geologist has been called on from time to time for assistance in matters relative to the state lands, and has aided the Commissioner of Immigration by furnishing such information as he requires relative to the soils and mineral resources. The Public Domain Commission has defrayed the entire expense of the first season's (1914) work on the investigation of Michigan wood lots and standing timber.

PROGRESS OF THE GEOLOGICAL SURVEY OF MICHIGAN

GEOLOGY.

The work of the Division of Geology during the biennium includes studies and field investigations of (1) the Gwinn Iron Bearing district, (2) the east end of the Menominee iron range between Waucedah and Escanaba, (3) the Gogebic iron range between Wakefield and Lake Gogebic, (4) continuation of laboratory studies of the pre-Cambrian rocks in the district between Lake Gogebic and Iron River, (5) the completion of a report on the copper deposits of Keewenaw point, (6) field investigations and preparation of a report on the geology of Limestone Mountain, (7) the completion and publication of a report on Michigan brine and salt deposits, (8) the completion and publication of a report on oil and gas in Michigan, (9) field investigations and laboratory studies of commercial limestone, (10) continuation of laboratory and field studies of the Dundee-Traverse formations, and (11) of the Marshall formation, (12) physiographic studies of Michigan inland lakes, and (13) geologic and physiographic studies of Mackinac Island.

Geological Work in the Gwinn Iron Bearing District.

The State Geologist devoted part of the fall season of 1913 to geologic study of the Gwinn synclinorium for the purpose of ascertaining the distribution, structure and correlation of the pre-Cambrian formations. The Upper Huronian group of the United States Geological Survey was found to include both the Upper and Middle Huronian groups of the Marquette district separated by a profound unconformity. The iron bearing series is equivalent to the Negaunee-Siama formations of the Marquette district. The manuscript and map were prepared for publication during the winter and were issued in preliminary form in the Journal of Geology, Volume 22, pages 560 to 573.

The work in the Gwinn synclinorium was followed by an examination of the Little Lake area, which revealed the presence of the Middle and Upper Huronian groups there as well as in the Gwinn district, thus establishing a basis for correlation with those in the Marquette district. An account of this work and

its results was prepared for publication during the winter and issued in preliminary form in the *Journal of Geology*, Volume 22, pages 574 to 581. In this work the State Geologist was assisted by Mr. L. P. Barrett.

Geologic Work on the East End of the Menominee Iron Range.

During the field season of 1913 geologic work designed to trace, beneath a thick cover of Paleozoic rocks and glacial drift, an eastern extension of the Menominee iron range was completed. Belts of magnetic variation were traced from Waucedah in Dickinson county eastward to Escanaba where they die out in Little Bay de Noc. Details of the magnetic mapping were executed in the field by Messrs. L. P. Barrett and H. J. Allen. A map and manuscript embodying the results of this work were prepared during the winter and issued in preliminary form in *Economic Geology*, Volume 9, pages 236 to 238.

Resurvey of the Gogebic Iron Range Between Wakefield and Lake Gogebic.

During the field season of 1914 Mr. L. P. Barrett, assisted by Messrs. Don T. McKone, M. C. Alverson and James Tobin, was engaged in field studies of the geology of the Gogebic iron range between Wakefield and Lake Gogebic. The field work was completed on November 1, 1914, and laboratory studies will be conducted during the winter. This work is already sufficiently far advanced to warrant the statement that the results are going to be of economic and scientific importance. It was ascertained that the Ironwood (iron bearing) formation of the Gogebic range does not appear east of section 22, T 47 N, R 43 W, being cut across and covered east of this locality by an unconformable series of quartzite, slate, and other sediments not known to contain iron ore. The discovery that there are three unconformable series of pre-Cambrian rocks in the Gogebic range instead of two as heretofore believed has an important bearing on pre-Cambrian correlations in the Lake Superior region, especially in Michigan.

Laboratory Studies of Pre-Cambrian Rocks in the District between Lake Gogebic and Iron River.

Field and laboratory work in preparation of a report on the district of pre-Cambrian rocks lying between Lake Gogebic and the Iron River district has been carried along and is now nearing com-

pletion. This work was begun in the summer of 1910 and has been continuously in progress since that time. The area which will be described in the report extends across the state boundary for some distance in Wisconsin, but no funds of the Geological Survey were devoted to work in Wisconsin. A description of the adjacent area in Wisconsin will be necessary for a proper understanding of the geology of Michigan adjacent to this portion of the state boundary. Publication of the results of several years of work in this area has been delayed pending the solution of certain problems of correlation, which was finally brought about satisfactorily through the results of the work above described on the Gogebic iron range.

Monograph on the Copper Ore Deposits of Michigan.

Mr. R. E. Hore has prepared for publication a monograph on the copper ore deposits of Michigan. This contribution is supplementary to that of Dr. A. C. Lane, whose work on the geology of the Keewenaw series was published in two volumes as Publication 6. A great deal has been written about the geology of the Keewenaw series, but relatively little attention has heretofore been devoted to a study of the copper ore deposits. Mr. Hore's work is a valuable contribution to the science of ore deposition and will be very useful to geologists and others interested in this phase of geology. The manuscript is fully completed and ready for printing.

Report on the Geology of Limestone Mountain.

Prof. E. C. Case assisted by Mr. W. I. Robinson devoted a part of the field season of 1913 to study and field mapping of the Paleozoic outliers near Keweenaw bay in Houghton county the more prominent of which is known as Limestone Mountain. An extensive collection of fossils was obtained which, with those already in the possession of the Survey, form an adequate basis for determination of the respective ages of the different strata. In addition to the determination of the stratigraphy of these rocks the quality, quantity, and availability of the limestone from an economic standpoint is considered in the report which is now finished and ready for publication.

A Report on the Brine and Salt Deposits of Michigan.

Dr. C. W. Cook has completed his work upon the brine and salt deposits of Michigan and has contributed a valuable manuscript on the subject. This manuscript was presented to the University of

Michigan as a thesis requirement for the degree of Doctor of Philosophy, and has been issued as Publication 15, Geological Series 12.

A Report on Oil and Gas in Michigan.

The most important work of Mr. R. A. Smith has been the preparation of an exhaustive report on the geology of oil and gas in Michigan. The manuscript, which was transmitted to the printer in July, has been printed and was sent to the bindery late in October. The report should be available for distribution by December 1, 1914. This report contains chapters on (a) stratigraphy and structure of the Paleozoic formations, (b) theories of origin and accumulation of oil and gas deposits with special reference to the anticlinal theory as applied to Michigan, (c) the general and specific conditions under which oil and gas are known to occur in Michigan, (d) the history of exploration in the various fields and districts of the state, and (e) complete records of all important deep borings.

Michigan Limestones.

During the fall and a portion of the winter of 1913-14, Mr. R. A. Smith continued his field and laboratory studies of Michigan limestones. The various limestone strata and groups of strata were mapped with particular reference to their economic character and geologic sections representing the stratigraphy of limestone formations in various localities were made. In July and August, 1914, particular attention was paid to the limestone resources of the northern part of the Southern Peninsula, developing the fact that practically unlimited amounts of high grade limestone occur in the counties of Alpena, Presque Isle, Cheboygan, Emmet, and Charlevoix. One or two weeks additional field work for study of the commercial limestones in Eaton, Wayne, and Monroe counties will be necessary to complete these investigations. The results of all of this work will be embodied in a report to be published in 1915, which is designed to meet the demand for information bearing on the distribution, character, and economic possibilities of the Michigan limestones in particular relation to the status of the limestone industry in general.

Studies of the Dundee, Traverse, and Marshall Formations.

Dr. A. W. Grabau has continued his studies on the paleontology and stratigraphy of the Dundee-Traverse formations, and Dr. Geo.

H. Girty has made considerable progress on the preparation of a monograph on the Marshall formation. Dr. Grabau's work is rapidly nearing completion, but it is not expected that Dr. Girty will be able to complete his monograph on the Marshall formation for some considerable time. These monographs will constitute the second and third numbers of a series which it is hoped will eventually include all of the systems of the Paleozoic. The first of these has been issued as Publication 2, Geological Series 1, the Monroe Formation, by A. W. Grabau and W. H. Sherzer. Co-operative arrangements have already been made with the United States Geological Survey for the preparation of a monograph on the Coldwater series of the Mississippian by Dr. Girty.

A Study of the Physiography of Michigan Inland Lakes.

Dr. I. D. Scott has completed field investigations and is now preparing a report on the physiography of Michigan inland lakes. The following is Dr. Scott's account of progress on this work:

"The state of Michigan is fortunate in sharing in the great number of inland lakes scattered over the territory formerly occupied by the ice sheet which spread over northeastern North America in Pleistocene times. The number of these bodies of water, large and small, within the state has never been accurately determined but it is estimated at more than five thousand, and their distribution covers almost the entire area of the state. Such bodies of water have an importance to a commonwealth that is far from being appreciated, although there is a growing tendency in this regard each year.

"It is true that much valuable land would be available for cultivation, if these lakes could be drained, but, in general, as lakes they are worth many times the acreage of their bottoms. This is well illustrated by the case of one of our small lakes situated in a farming community. In the lake is an island of about fifty acres which is assessed at \$1,000.00 per acre for purposes of taxation while the land not situated on the lake bears an assessment of \$100.00 per acre or less.

"The value of lakes to human beings is varied. Some of the valuable things which they have supplied are water for logging purposes, power, navigation, and municipal water supply, food (fish), ice and fuel (peat), and rich soils from extinct lake beds, and recreation. The value of inland lakes for recreative and educational purposes can not be over estimated. There are few lakes in Michi-

gan of a square mile or more in area which are not used for recreation and many thousands of dollars is invested in summer homes and hotels on a large number of Michigan lakes. Furthermore, the summer population on Michigan lakes is rapidly growing. With this growth an active and increasing interest is being shown in the scientific study of lakes and the practical application of the facts thus determined in the selection of locations for summer homes.

"The educational opportunities offered by inland lakes are also important. There are about 350 high schools in the state and at least 75% of them offer courses in physical geography or geology and the lakes afford to the students of these subjects valuable opportunities for direct observation.

"The field work in connection with these studies occupied the summer months of 1913 and 1914. It was of course impossible to study all of the Michigan lakes. The factors which governed the selection of lakes for examination were (1) size (shore adjustments are likely to be more pronounced on the larger lakes), (2) type of basin, (3) location, and (4) importance as a resort. The work included an examination of the surrounding topography in order to determine the origin of the basin, a traverse of the shores by boat, on foot, or both for the purpose of studying the adjustments of the present level and, wherever time permitted, the former levels, and a limited number of soundings to determine the lower limit of wave action.

"Accurate topographic and hydrographic maps would have been of great assistance but these were not available except in a few cases. It was found necessary in many instances to make use of the United States Land Survey plats.

"The lakes which are examined are: Northern Peninsula—Chicagon, Cisco lakes, Michigamme, Gogebic, Huron Mountain group (Pine, Mountain, Canyon, Rush and Conway), North Manistique, South Manistique, Portage, Torch, Teal, Brevort and Indian. Southern Peninsula—lakes of the Inland Route (Crooked, Burt and Mullett), Black (Cheboygan county), Douglass, Walloon, Torch, Elk, Pine (Charlevoix county), Carp (Leelanau county), Crystal (Benzie county), Pere Marquette, Manistee, Muskegon, Spring, Gunn, Big Clam, Little Clam (Wexford county), Portage (Crawford county), Higgins, Houghton, Otsego, Sunken (Presque Isle county), Long (Alpena county), Hubbard, Orchard, Cass, Long (Genesee county), and Corey, Clear, Long and Klinger in St. Joseph county.

"Some of these were found unsuitable for study but most of them

were traversed and many important and interesting adjustments of the shores by waves and ice action were found. A surprisingly large amount of modification of the shores by ice action was found and the observations may aid in determining the relative importance of ice expansion and ice jam as agents of deformation of the shores of small lakes. Ten different types of basins were differentiated and, of these, all but three are due to glacial action. It seems clear that there has been a general lowering in level of the lakes, not recent in age, cause of which has yet to be determined.

"The report will consist of two parts. Part 1 is intended to familiarize the lay reader with the manner of formation of lake basins, the forces which are active on the shores, the effects of these forces, and the processes through which lakes eventually become extinct. It includes a general statement of the topography of Michigan, a brief discussion of the work of running water and glaciers, a classification of lake basins and the manner of formation of the types found in this state, a statement of the work of waves, currents and ice and the resultant forms.

"Part 2 will contain descriptions of the shores of the various lakes treated individually. The physiographic forms and the manner of their formation will be discussed together with an account of the origin of the basin and the factors working towards the extinction of the lake."

Geologic and Physiographic Studies of Mackinac Island.

Probably no other locality in Michigan holds more of historical interest than the Island of Mackinac. Its natural beauty combined with its location have made it the most popular of Michigan's summer recreation grounds. A considerable part of the island is under the administration of the Mackinac Island State Park Commission, which is doing a commendable work of improvement and beautification and is maintaining and preserving the old buildings and military works of historical interest.

The geologic history of Mackinac Island is no less fascinating than its human history for there is recorded in the series of abandoned beaches, bars, spits, stacks, sea cliffs, and other shore features, a large part of the history of the ancestral Great Lakes. At the highest or Algonquin stage of the Great Lakes, Mackinac Island consisted of only a few acres of ground forming the highermost part now occupied by old Fort Holmes. As the waters of the ancient Great Lakes receded from their earlier shore lines and fell to lower and lower levels until the present stage was reached each

successive lower stage was marked by its corresponding shore line features on the Island of Mackinac.

In the mapping and interpretation of these natural features of Mackinac Island the Geological Survey is not only doing an important educational work but is also furthering the plan of the Mackinac Island State Park Commission to add to the interest and enjoyment of the several hundred thousand people who annually visit the island. During the summer season of 1914 field investigations were completed, and it is planned during the winter to construct a map of the Island on a rather large scale on which the geologic and physiographic features will be delineated, this map to be accompanied by a brief descriptive text. It is also planned to call attention to the meaning and interpretation of the natural features of the island through a system of guide posts and signs to be erected by the Mackinac Island Park Commission. The work on Mackinac Island is in charge of Mr. Frank B. Taylor to whose indefatigable labors we are indebted for much of our present knowledge of the history of the Great Lakes.

MINERAL RESOURCES AND STATISTICS OF MINERAL PRODUCTION.

By an unanimous vote of both houses of the legislature, session of 1911, the duties formerly devolving on the Commissioner of Mineral Statistics were transferred to the Board of Geological Survey by the following Act:

Act No. 7, Public Acts, Session of 1911.

AN ACT to repeal act number nine of the public acts of eighteen hundred seventy-seven, entitled "An act to authorize the appointment of a Commissioner of Mineral Statistics, and defining the duties and compensation of the same," approved February eight, eighteen hundred seventy-seven, as amended, being sections four thousand six hundred thirty, four thousand six hundred thirty-one, four thousand six hundred thirty-two, four thousand six hundred thirty-three, four thousand six hundred thirty-four and four thousand six hundred thirty-five of the Compiled Laws of eighteen hundred ninety-seven; to abolish the office of Commissioner of Mineral Statistics; and to provide for continuing the duties of said commissioner under the direction of the State Board of Geological Survey.

The People of the State of Michigan enact:

Section 1. Act number nine of the public acts of eighteen hundred seventy-seven, entitled "An act to authorize the appointment of a Commissioner of Mineral Statistics, and defining the duties and compensation of the same," approved February eight, eighteen hundred seventy-seven, as amended, being sections four thousand six hundred thirty, four thousand six hundred thirty-one, four thousand six hundred thirty-two, four thousand six hundred thirty-three, four thousand six hundred thirty-four and four thousand six hundred thirty-five of the Compiled Laws of eighteen hundred ninety-seven, is hereby repealed.

Sec. 2. The duties of the Commissioner of Mineral Statistics, as defined by said act number nine of the public acts of eighteen hundred seventy-

seven, are hereby transferred to the State Board of Geological Survey, and it is hereby declared to be their duty to continue the collection of statistics, the conducting of investigations, the making of reports, and all other duties as specified in said act number nine of the public acts of eighteen hundred seventy-seven.

Sec. 3. The office of Commissioner of Mineral Statistics, as provided for under said act, is hereby abolished, and the incumbent of said office is hereby directed and required to transfer and turn over to the State Board of Geological Survey all the books, papers, maps and other documents of said office, upon the taking effect of this act, and the salary and emoluments of said Commissioner of Mineral Statistics shall from that time cease.

Sec. 4. All acts or parts of acts in anywise contravening the provisions of this act, are hereby repealed.

Sec. 5. The enactment of this act is necessary for the public peace and safety.

This act is ordered to take immediate effect.

Approved March 13, 1911.

*The Annual Report on Mineral Resources and Statistics of
Mineral Production.*

The character and execution of the annual report is governed by the following considerations:

1. It should appear promptly at the end of each year.
2. It should bear complete statistics for all branches of the mineral industry, including metallic and non-metallic products.
3. It should contain a general resumé of current conditions of the mineral industry with special reference to new exploration and the bearing thereon of possible extensions of known mineral producing areas and the discovery of new ones.
4. It should contain a directory of the mineral producers.
5. Special subjects of current importance and interest to the mineral industry should receive careful treatment.

The statistical tables which appear in these reports are compiled from the statements of the mineral producers, secured under joint action of the state and federal surveys, with the exception of those relating to copper, iron ore, coal, and pig iron to which this co-operation does not extend.

The figures of productions and values are published in such detail as is permissible, having in mind the business interests of the individual producers. Much of the more important material in these reports is given wider circulation than would otherwise be possible through the medium of the technical and trade journals, but for purposes of reference and permanent record the bound volumes are indispensable.

The annual report for 1911 was issued as Publication 8, Geological Series 6; for 1912, Publication 13, Geological Series 10; and for 1913, Publication 16, Geological Series 13.

PROGRESS OF THE TOPOGRAPHIC SURVEY OF MICHIGAN.

The ultimate aim of the topographic survey is the completion of a map of the state in units of 15' of latitude by 15' of longitude, each unit or *quadrangle* being issued as a separate sheet. The area of a quadrangle is approximately 200 square miles. With the exception of certain areas such as state forests, state parks, certain mining districts, flat lands, etc., where a larger scale and smaller vertical contour interval may be advisable, the scale of each quadrangle map will be 1:62500, and the vertical interval between contour lines will be for some quadrangles 10 feet and for others 20 feet. Each quadrangle map will exactly register with others east, west, north and south of it making it easy wherever advisable to combine a number of the quadrangles to form a map of larger area such as a county, a drainage system, a mining district, or a natural industrial or physiographic province.

The topographic mapping of Michigan is contributory to the completion of a topographic map of the United States. This work is being executed by the government of the United States acting through the United States Geological Survey and in co-operation with many of the states. On June 30, 1914, 1,197,782 square miles or 39.6% of the area of all of the states had been topographically mapped.

The topographic mapping of the state of Michigan in co-operation with the United States Geological Survey began in 1901 when allotment for such work was made by the Director of the United States Geological Survey. Since 1901 the expenditure by the state and federal governments for co-operative topographic mapping in Michigan has been as follows:

EXPENDITURES FOR CO-OPERATIVE TOPOGRAPHIC SURVEY OF MICHIGAN.

Year.	By the State of Michigan	By the United States Geological Survey.
1903.....	\$800 00	\$800 00
1905.....	2,000 00	2,000 00
1906.....	3,000 00	3,000 00
1907.....	3,000 00	3,000 00
1908.....	2,000 00	2,000 00
1909.....	2,000 00	2,000 00
1910.....	2,000 00	2,000 00
1911.....	2,000 00	2,000 00
1912.....	2,000 00	2,000 00
1913.....	2,500 00	2,500 00
1914.....	2,500 00	2,500 00

On June 30, 1914, there had been mapped in the State of Michigan 5,745 square miles or 10% of the area of the state, including in the Southern Peninsula the Wyandotte, Romulus, Ypsilanti, Saline, Dexter, South Lyon, Wayne, Detroit, Grosse Point, Rochester, Pontiac, Milford, Howell, Fowlerville, Mason, Lansing and Grand Rapids quadrangles, and in the Northern Peninsula the Calumet special, Houghton, Marquette, Menominee special, Ned Lake, Perch Lake, Witbeck, Iron River, Crystal Falls and Sagola quadrangles. The latter six quadrangles were mapped before the present standards of topographic work were in force and these sheets are considered as merely reconnaissance.

An enumeration of the quadrangles of which topographic surveys have been made and maps completed and published does not account for all of the work which has been done in Michigan, for many miles of primary control lines have been established through areas of which no maps have been made. A certain amount of these lines are established each year and gradually these lines of horizontal and vertical control are being pushed forward to form a network covering the entire state. This work is a necessary preliminary to the completion of the topographic map. The results of triangulation and primary traverse in Michigan in 1911 and 1912 were recently published by the United States Geological Survey.*

THE PLAN OF CO-OPERATION IN TOPOGRAPHIC MAPPING.

It has been found by experience in many states that the best results in topographic mapping are obtained through co-operation with the federal government. The United States Geological Sur-

*Bulletin No. 551, U. S. Geological Survey, 1914.

vey maintains a large organization of trained topographic engineers with ample equipment and experience necessary for the attainment of lowest possible cost consistent with a high standard of work. Furthermore the United States government is pursuing a plan of making a topographic survey of the whole country under a uniform plan applicable to all of the states and it is desirable that such topographic work as may be undertaken by the several states or by them in co-operation with the United States should conform to this general plan or should be of such character that it may be adapted to this plan without additional expense for field surveys.

The plan of co-operation in force in Michigan at the present time, which is practically the same as that in force in other co-operating states, is set forth below in the articles of agreement of July, 1913, between the Director of the United States Geological Survey and the State Geologist of Michigan.

AGREEMENT between the Director of the United States Geological Survey and the State Geological Survey of Michigan for the continuation of the co-operative topographic survey of the State of Michigan, as provided for in an act passed by the State Legislature, 47th session, and signed by the Governor May 13, 1913.

1. The preparation of the map shall be under the supervision of the Director of the United States Geological Survey, who shall determine the methods of survey and map construction.

2. The order in which, in point of priority, different parts of the State shall be surveyed shall be agreed upon in detail by the State Geologist of Michigan and the Director of the United States Geological Survey, or their respective representatives.

3. The survey shall be executed in a manner sufficiently elaborate to prepare a map upon a scale of 1:62,500, exhibiting the hydrography, hypsography, and public culture, and all town and county boundary lines, township and section lines, as marked upon the ground at the time of its completion, in form similar to sheets already completed in the State of Michigan. The preliminary field maps shall be on such scale as the Director of the United States Geological Survey shall select to secure accuracy in the construction of the final map.

4. The hypsography shall be shown by contour lines, with a vertical interval of 10 or 20 feet.

5. The heights of important points shall be determined and furnished to the State Geologist of Michigan.

6. The outlines of wooded areas shall be represented upon proofs of the engraved map to be furnished to the State Geologist of Michigan.

7. For convenience, the United States Geological Survey shall pay, during the progress of the field work, the salaries of the permanent employees engaged thereon; while the traveling, subsistence, and field expenses shall be paid for the same time by the State. During the office season the salaries shall be divided in such a way as to equalize all expenses, provided that the total cost to the State of Michigan for field and office work shall be not less than two thousand, five hundred (\$2,500), and provided that the United States Geological Survey shall expend an equal amount upon the work before June 30, 1914, the Federal allotment to bear an approximate charge of 12½ per cent for the necessary expenses in connection with the proper execution of the field and office work. All accounts shall be approved by a representative of the United States Geological Survey before payment.

8. During the progress of the work, free access to the field sheets and records of the topographers and draftsmen shall be afforded the State Geologist of Michigan, or his representative, for examination and criticism; and should the said State Geologist deem that the work is not being executed in a satisfactory manner, then he may, on formal notice, terminate this agreement.

9. The resulting maps shall fully recognize the cooperation of the State of Michigan.

10. When the work is completed, the State Geologist of Michigan shall be furnished by the United States Geological Survey with photographic copies of the manuscript sheets; and when the engraving is completed, and at all times thereafter when desired, he shall be furnished by the said Survey with transfers from copper plates of the maps for use in printing editions of said maps.

MEMORANDUM giving areas proposed for survey under this agreement by the Topographic Branch of the United States Geological Survey in cooperation with the State Geologist of Michigan, for the period beginning July 1, 1913, and ending June 30, 1914;

The completion of the mapping of the St. Charles quadrangle, and so much of the mapping of the Centerville quadrangle as the funds will permit.

Washington, D. C.,

GEO. OTIS SMITH,

July 1, 1913.

Director, U. S. Geological Survey.

Lansing, Michigan,

R. C. ALLEN,

July 5, 1913.

State Geologist of Michigan.

REPORT OF TOPOGRAPHIC SURVEYS IN CO-OPERATION BETWEEN THE
UNITED STATES GEOLOGICAL SURVEY AND THE STATE OF
MICHIGAN FOR THE FISCAL YEARS BEGINNING JULY
1, 1912, AND ENDING JUNE 30, 1914.

In accordance with the co-operative agreements signed August 24, 1912, and July 1, 1913, by George Otis Smith, Director, for the United States Geological Survey, and by R. C. Allen, State Geologist, September 2, 1912, and July 5, 1913, for the State of Michigan, the Federal Survey allotted \$2,000 and \$2,500 respectively, and the State equal amounts, for co-operative topographic surveys in the State of Michigan during the fiscal years beginning July 1, 1912, and ending June 30, 1914.

The following is a summary of the field and office work accomplished during the above period under the general direction of R. B. Marshall, Chief Geographer, and under the immediate supervision of W. H. Herron, Geographer of the Central Division.

FIELD WORK.

Quadrangles.	Counties.	For publication on scale of	Area mapped sq. mi.	Primary Levels.		Traverse.		
				Miles.	Perm. B. M's.	Primary.		Sec'd'y Miles.
						Miles.	P. Marks.	
Burt.....	Genesee, Livingston, Shiawassee					8	1	
Carson City.....	Clinton, Gratiot.....					9	1	
Centerville.....								
(Mich. por.).....	St. Joseph.....	1:62,500	59	90	16	47	4	445
Cheesaning.....	Saginaw.....			15	4	16	1	
Coldwater.....	Branch.....			16	4			
Corunna.....	Ingham, Livingston, Shiawassee			20	5	12	1	
DeWitt.....	Clinton, Eaton.....					11	1	
Durand.....	Genesee, Livingston, Shiawassee					12	1	
Elsie.....	Gratiot, Saginaw.....					6	1	
Freeland.....	Midland, Saginaw.....					8	1	
Grand Rapids.....	Allegan, Kent, Barry.....	1:62,500	192			7		839
Ithaca.....	Gratiot.....						1	
Kalamazoo.....	Allegan, Barry, Kalamazoo.....			21	5	15	2	
Merrill.....	Gratiot, Midland.....					11	1	
Muir.....	Clinton, Eaton.....							
Perrinton.....	Clinton, Gratiot.....					16	2	
Reading.....	Branch, Hillsdale.....			15	5			
Saginaw.....	Bay, Saginaw.....			16	4	12	1	
St. Charles.....	Midland, Saginaw.....		95	85	20	47	4	
Schoolcraft.....	Kalamazoo, St. Joseph.....	1:62,500		21		8	1	
Sturgis.....								
(Mich. por.).....	Branch, St. Joseph.....			14	4	12	1	
Wayland.....	Allegan, Barry.....			21	7			
Total.....			346	334	74	257	25	1,284

The following members of the United States Geological Survey were engaged in the field work:

Topographic Mapping:

C. L. Sadler, Topographic Engineer.
A. M. Walker, Topographic Engineer.
L. L. Lee, Assistant Topographer.
L. D. Townsend, Junior Topographer.
H. E. Burney, Junior Topographer.

Primary Traverse:

J. H. Wilson, Junior Topographer.

Levels:

E. C. Bibbee, Topographic Aid.
R. G. Clinite, Junior Topographer.

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TABLE SHOWING PROGRESS OF THE TOPOGRAPHIC SURVEY IN THE UNITED STATES.*

State.	Surveyed 1912-1913. Square miles.	Total surveyed to June 30, 1913. Square miles.	Percentage of total area surveyed to June 30, 1913.	State appropria- tion. 1912-1913.	U. S. appropria- tion. 1912-1913.
Connecticut.....		4,965	100		
District of Columbia.....		70	100		
Massachusetts.....		8,266	100		
New Jersey.....		8,224	100		
Rhode Island.....		1,248	100		
West Virginia.....		24,170	100	\$12,000	\$10,000
Maryland.....		12,327	100		
New York.....	622	42,227	85	10,000	10,000
Ohio.....	1,739	34,727	84	25,000	10,000
Utah.....		67,905	79		
Kansas.....		64,159	78		
Virginia.....		29,980	70	4,250	4,250
California.....	6,133	109,444	69	14,000	14,000
Arizona.....	2,299	66,760	58		
Oklahoma.....	397	39,612	56	1,000	1,000
Pennsylvania.....	291	24,167	55	5,328	5,328
Missouri.....	185	35,664	51	2,500	2,500
Delaware.....		1,202	51		
Tennessee.....		20,911	50		
Nevada.....	7	50,682	46		
Kentucky.....	67	17,654	43	10,000	10,000
Colorado.....	1,131	45,226	42		
Arkansas.....		21,380	40		
Vermont.....		3,753	39		
Montana.....	794	55,965	38		
Alabama.....		18,713	36		
New Hampshire.....		3,380	36		
Nebraska.....	217	26,311	34	2,000	2,000
North Carolina.....		17,661	34		
Washington.....	650	23,269	33	13,750	13,750
Georgia.....		17,337	29		
Idaho.....	382	24,462	29	700	700
New Mexico.....	320	35,850	29		
Wyoming.....	157	27,538	28		
Maine.....	294	8,914	27	3,650	3,850
Texas.....		67,387	25		
South Dakota.....		18,594	24		
Illinois.....	1,018	13,128	23	8,000	8,000
Wisconsin.....		11,789	21		
Oregon.....	930	20,742	21	15,000	15,000
Iowa.....	305	11,371	20	2,650	2,350
South Carolina.....		5,640	18		
Louisiana.....		8,311	17		
North Dakota.....		9,716	14		
MICHIGAN.....	206	5,591	9	2,000	2,000
Indiana.....		3,041	8		
Minnesota.....	434	5,572	6	10,362	10,000
Mississippi.....		1,889	4		
Florida.....		2,080	4		
Total.....	18,578	1,178,974	38.9	\$142,190	\$124,728

*From Thirty-fourth Annual Report of the Director of the U. S. Geological Survey.

PROGRESS OF THE BIOLOGICAL SURVEY.

The powers and duties of the Board of Geological Survey relative to the biological survey of the State are defined in Act number 250 of the laws of 1905 as follows:

AN ACT to provide for a biological survey of the State, making appropriation therefor, and to provide a tax to meet the same.

The People of the State of Michigan enact:

Section 1. That the Board of Geological Survey as constituted by act number sixty-five of the laws of eighteen hundred sixty-nine, as amended, is hereby authorized and required to make under the general direction of the State Geologist, appointed by them, a thorough biological survey of the State, embracing a determination of the range and distribution of the various plants and animals inhabiting the State and the relation of their environment and the welfare of man.

Sec. 2. The powers and duties of said board relative to the expenses incident to such biological surveys, and the publication thereof shall be the same as they now are relative to the geological and mineralogical survey of the State.

Sec. 3. The annual report of progress now required of the Board of Geological Survey shall include an account of the progress of said biological survey and there shall be printed of the same, the same number as, and under the same conditions as, the report of the Board of Fish Commissioners as provided in act number two hundred twenty-five of the public acts of nineteen hundred three.

The biological survey is supervised by Dr. A. G. Ruthven, Chief Naturalist, who submits the following report of progress for the two fiscal years ending June 30, 1914.

General Statement.—The biological work of the Survey during the past two years has been carried on according to the plan that has governed the operations of the biological division since its inception. The survey of different sections of the state has been continued, monographic studies of the different groups of animals and plants in the state have been arranged for, and assistance has been given to local naturalists who are engaged in investigations within the state which will add to our knowledge of the Michigan fauna and flora.

It is evident that the Survey cannot, with its limited appropriation, give to any one piece of work sufficient support to insure its early completion, unless the investigation be very limited in scope, or all other work be stopped. It has not seemed advisable to limit

the activities of the Survey either to minor investigations or to a single narrow field of investigation, so that the policy has been adopted of extending each study over a term of years. The investigators are required to make a report after each field season, the facts of immediate interest are published in scientific journals, and the reports of each investigation are filed, so that those which relate to the same subject may be published together when the whole work has been completed.

Field Work.—The field work of the past two years was as follows:

1913.

An investigation of the flora of the east coast of Michigan, by C. K. Dodge.

A statistical study of some Michigan oaks, by H. Hus and H. Otis.

A field study of the reptiles and amphibians of the eastern part of Monroe county, by Crystal Thompson.

Biological Survey of Whitefish Point, Michigan:

Birds and mammals, by N. A. Wood and Frank Novy.

Flowering plants, by C. K. Dodge.

Lower plants, by A. H. Povah.

Beetles and flies, by A. W. Andrews.

An investigation of the reptile-amphibian fauna of the region about Manistee, Michigan, by Crystal Thompson.

The work of Mr. Dodge may be considered as a continuation of the exhaustive study of the flora of the state in which he has been engaged for several years. In 1913, he examined the flora of Mackinac Island, Bois Blanc Island, the region about Mackinaw City, and the country along the shores of Lake Michigan and Lake Huron at various places north of Saginaw Bay and Cheboygan. Large collections of specimens were made, a part of which have been sent to the Michigan Agricultural College, the depository of the botanical specimens of the Survey. A report of the work has been received by the Chief Naturalist, and the data for Mackinac Island has been published so that it may be available for the use of the residents.

The field work of 1914 was done at Whitefish Point in order that it might be made to contribute to the survey of the point which was in progress, as well as to the investigation of Mr. Dodge. According to a preliminary report, the work was successful, and

the whole region covered by the survey was as thoroughly studied as time permitted in the late spring and summer.

The assistance given to the statistical study of some Michigan oaks that is being made by Dr. Henri Hus, of the University of Michigan, has materially advanced the work. The investigation is to extend over five years, of which three remain, so that the results will not be published until about 1916. The final report should be an important contribution to our knowledge of the group.

The publication of "The Herpetology of Michigan"¹ emphasized the fact that there were still considerable areas in the state from which little or no data on the reptile-amphibian fauna was at hand, and as it is desirable that the fauna of some of these regions be examined as soon as possible, owing to the changes incident to the clearing and cultivation of the land, Miss Crystal Thompson was sent to Monroe county in 1913 and to Manistee county in 1914 to study these groups. It is sufficient to say that a large amount of information on the reptiles and amphibians of the two regions was secured, thus increasing our knowledge of the distribution of the groups within the state.

The study of the flora of Wayne county by Mr. Forest Brown was a continuation and the completion of an investigation which was begun for the Geological Survey before the inception of the biological division. It was desirable that another season be devoted to the field work before the preparation of the final report, and the Survey bore the expense of this work with the understanding that upon its completion the complete report would be submitted.

The survey of the Whitefish Point region in 1914 included an examination of the spring and summer birds, the mammals, the beetles and flies, and the flowering and non-flowering plants, as stated above. Five men were placed in the field for various periods of time, and the five groups were studied in detail and from the ecological aspect. This material is now being studied and reports upon the birds and mammals have been submitted. To the data gathered in 1914 will be added the results of an investigation of the amphibians, reptiles, fishes, summer birds and mammals made in 1912 and 1913 by the Museum of Zoology, University of Michigan, with the support of Hon. George Shiras III, so that a rather comprehensive report may be published without more field work.

¹Publication 10. Biological Series 3.

Publications.—As none of the major pieces of work which the biological division has begun were finished, no final reports have been published during the two years covered by this report. Several short papers have appeared or are in press, and the monograph on the Michigan fungi of the family Agaricaceae, by C. H. Kauffman, and the reports of the surveys of the Charity Islands, and the study of the flora of Wayne county, by Forest Brown, are practically ready for publication.

The papers that have appeared are as follows:

The Flowering Plants, Ferns and their Allies of Mackinac Island, Michigan, by C. K. Dodge. 15th Ann. Rept. Mich. Acad. Sci., pp. 218-237.

Notes on Crustacea Recently Acquired by the Museum, by A. S. Pearse. Occ. Papers Mus. of Zool., Univ. of Mich., No. 1, pp. 1-4.

An Annotated Check-list of Michigan Mammals, by N. A. Wood. Occ. Papers Mus. of Zool., Univ. of Mich., No. 4, pp. 1-13, 1 map.

Those in press are:

Observations on the Fishes of Houghton County, Michigan, by Thomas L. Hankinson.

A Catalog of the Flora of Isle Royale, Lake Superior, by William S. Cooper.

Results of the Shiras Expeditions to Whitefish Point, Michigan. Birds, by Norman A. Wood.

The Birds of Dickinson County, Michigan, by Frederick M. Gaige.

Recommendations.—The Chief Naturalist suggests that during the coming year (1915) the Survey continue the investigation of the phanerogamic flora of the state and begin a survey of the woodlots of Michigan, a monograph on Michigan fishes, and a study of the economic importance of the beaver. Each of these pieces of work should yield practical as well as scientific results, and there is urgent need for the information of an economic nature that may reasonably be expected.

RECOMMENDATIONS TO THE LEGISLATURE.

Approved by the Board of Geological Survey, Nov. 25, 1914.

RELATIVE TO A PROPOSED INCREASE IN APPROPRIATIONS FOR TOPOGRAPHIC MAPPING.

Why Should the State of Michigan be Topographically Mapped?

In view of the fact that the federal and state governments are spending in excess of a half million dollars yearly on topographic surveys it may be supposed that the results are generally regarded as being of important and immediate usefulness. The need for a topographic map of Michigan is not less pressing than in the other parts of the country, in fact the need is greater here than in some other states which have a smaller proportion of undeveloped lands and fewer or less important problems relating to drainage, soils, road building, the conservation of water powers, etc.

In general, topographic maps are useful for the solution of all problems and for the consummation of all projects which depend in any measure on a knowledge of the configuration of the surface of the ground; i. e., the "lay of the land" in addition to bare facts of location of things natural and artificial, such as lakes, streams, swamps, highways, surveyed lines, railroads, buildings, drains, etc. A good topographic map shows the altitude of all places within very narrow limits, depending on the vertical distance between contours, and the form or shape and extent of all features of the surface such as hills, valleys, slopes, plains, etc.

1. Use of Topographic Maps in Planning Drainage.

Good drainage is essential to all areas under cultivation. There are thousands of miles of artificial drains in Michigan ranging in importance from the tile line a few rods in length to the master ditch many miles in length. In so far as drainage is a purely local problem involving slight expenditure for a tile drain or a short ditch a topographic map is not essential, but when large areas are involved and trunk lines with tributaries are to be established, i. e. *an artificial drainage system*, a topographic map is *absolutely essential* to a proper consideration and plan of the work. Enormous expenditures have been made in preliminary surveys which would have been saved were topographic maps available. A topographic map is particularly essential when two or more local governmental units are engaged in joint drainage projects as they

serve as a basis for preliminary and in many cases final plans on which costs are prorated. There are millions of acres of wet lands in Michigan which must be drained before they can be subjected to cultivation. An intelligent and economic prosecution of the work of draining our swamp lands is not possible in areas lacking topographic maps.

In the Control of Stream Flow and Conservation of Water Power. Involved in the general problem of drainage is the control of stream flow. The removal of forests and cultivation of the land has seriously accentuated high and low water stages in many of our streams. This condition establishes flood stages on the lower courses of streams which traverse flat lands. In the Saginaw Valley spring floods are becoming a serious menace and it has been proposed to divert the waters of the Tittabawassee to the Kawkawlin in order to relieve the lower valley of the Saginaw. The control of stream flow purposes not only to relieve flood conditions but to conserve where possible the water for use in power plants. But whether one or the other or both of these objects are involved it is essential that the area of the catchment basins of the streams and their total fall and fall per mile, etc., in different parts of the courses, the width, depth, and general configuration of their valleys, etc., be known before any intelligent plans may be formulated. A good topographic map supplies all of this data.

2. In the Study of Soils. Elsewhere in the report I have discussed the importance of a scientific classification and mapping of soils as a basis for extensive study of soil types. The general physiography of soils is a factor of prime importance in agriculture and has a strong bearing on land values. Michigan soils are of glacial and fluvio-glacial origin and particular soil types are to large extent characteristic of particular topographic forms. In other words, there is a general relationship between the configuration of the surface and the character of the underlying soil formations. Soil maps lose much of their practical value if they are not constructed on a topographic base.

3. In the Construction of Highways. Michigan has entered on a policy of state control over the construction of highways, particularly of main or trunk line highways. Large sums of money are expended in the preliminary location or survey of public roads which could be saved were good topographic maps available. The same applies to the location of electric and steam roads, railroad aqueducts, telephone lines, telegraph lines, and power transmission lines such as electric, water, and air pipe lines.

4. For Military Purposes. All military operations in the field are affected and in large measure governed by the character and configuration of the surface. The topographic maps of the United States will constitute a military map and will be useful in the development of plans for offense and defense. In the consideration of strategical movements of the troops, particularly of artillery and cavalry, topographic maps are essential.

There are many other important uses of topographic maps, some of which are mentioned below.

5. For improving rivers and smaller waterways.

6. In making investigations for the improvement of the plant and animal industries, and in a comprehensive study of physical and biological conditions in connection with the stocking of interior water with good fish and the locating of fish culture stations.

7. In locating and mapping the boundaries of life and crop zones, and in mapping the geographic distribution of plants and animals.

8. In plotting the distribution and spread of injurious insects and germs.

9. As a base map for the plotting of information relative to the geology and mineral resources of the country.

10. In connection with questions relating to state, county and town boundaries.

11. As a means of promoting an exact knowledge of the country and serving teachers and pupils in geographic studies.

12. As base maps for the graphic representation of all facts relating to population, industries, and products or other statistical information.

14. In connection with legislation involving the granting of charters, rights, etc., when a physical knowledge of the country may be desirable or necessary.

Relative to Appropriations for the Topographic Survey.

It was stated above that only 10% of the area of Michigan has been topographically mapped. The percentage for the entire country is 39.6%. We are thus about 30% behind the country at large. Of the 48 states in the union Michigan ranks forty-fourth in the percentage of area surveyed (see table). That Michigan has fallen so far behind is mainly due to her failure to take fuller advantage of the plan of cooperation offered by the federal government. The Federal Survey offers to meet dollar for dollar, up to a reasonable limit, any appropriation the various states may make for topographic mapping. Many states have taken full advantage of this

offer and others have gone even farther and have offered more money than the federal government could meet. In comparison with the neighboring state of Ohio, for instance, the Michigan allotments for co-operation seem insignificant (see table). The results of the liberal policy in Ohio are apparent when one realizes that the entire area of the state will be covered by modern topographic maps within the next year and that more than 91% of the state has been completely mapped already.

Michigan can well afford to take much fuller advantage of the liberal offer of co-operation which is made by the federal government and appropriate much more liberally for this purpose than heretofore. The cost of a topographic map varies with the character of the country. An open country which is well dissected by roads may be mapped at less cost than a wooded or undeveloped country. The cost of the work in the Southern Peninsula has been about $1\frac{1}{2}$ cents per acre to the state and the same amount to the federal government. But in addition to the areas actually mapped many miles of control lines have been run. It is probable that the cost would be materially reduced were the operations conducted on a larger scale.

The appropriations granted heretofore for co-operative topographic mapping in Michigan are so small that reasonable progress toward completion of a map of the state can not be made thereunder. The federal government offers to co-operate with Michigan in this work up to any amount not exceeding twenty thousand dollars (\$20,000) per annum. With an annual expenditure of \$15,000 by the state progress could be made at the rate of 8 to 10 quadrangles per annum.

RELATIVE TO WATER POWERS, DRAINAGE, ETC.

There is no public source of reliable information relative to the possibilities of power development in our streams nor any source of public information regarding those streams which have been developed wholly or partially by the power companies. In many parts of the state drainage problems have become acute, as for instance in the Saginaw Valley. About 10 years ago the United States Geological Survey undertook the gaging of streams on a large scale and a beginning was made in Michigan. The curtailment of funds for this purpose by congress terminated the work in Michigan as well as in some other states and since that time nothing has been done excepting only the maintenance of a gage on the Escanaba river, the expense of which has been borne by this Survey for a number of years past.

Although the matter of the investigation of the water powers and drainage problems has commanded the attention of the Michigan Engineering Society for a number of years, as well as other organizations and individuals, no definite steps have been taken in the matter up to this time beyond the passage of resolutions favoring inauguration of work by the state.

As a matter of fact progress along these lines is bound up with and in large part dependent on the topographic survey. Topographic maps are needed for the calculation of the areas of catchment basins, the proportion between run-off and evaporation, the fall of streams, etc. Topographic maps are also needed as an almost indispensable aid in the development of extensive artificial drainage systems. In other words all problems relating to drainage and the utilization of water power are dependent for their solution on an accurate knowledge of the configuration of the surface or in common phraseology "the lay of the land."

I have urged on the legislature in two successive sessions the importance of an early completion of the topographic map of the state, and while I deem the investigation of drainage problems, water supplies, etc., of prime importance I believe that economy as well as due regard to usefulness of the results demand that these investigations await further progress with the topographic survey.

RELATIVE TO A SOIL SURVEY OF MICHIGAN.

Section 4 of Act No. 250 of the laws of 1869* places upon the Board of Geological Survey the duty of making, or causing to be made, "*an investigation of soils and subsoils, and the determination of their character and agricultural adaptation.*"

The investigation of soils has always commanded a share of the attention of the Survey. But in recent years soil study and mapping has occupied a more prominent place in its work than formerly although the resources at command have been insufficient for progress in this direction in keeping with the importance of the work to the development of agriculture or with the emphasis apparently laid upon it by the legislature.

Agriculture must always remain the fundamental basis of industry in Michigan as in the nation. The value of crops exceeds annually that of the mineral products and the soil formations are of greater economic importance than all others which concern the work of the geologist. Economists and agriculturists are deeply concerned with the problem of increasing per capita crop production in this country. Obviously this can be done in either or both of two ways, viz., by increasing the cultivated acreage or by increasing acreage yield. Since the ratio of urban to rural population is rising in the face of the steady settlement of the remaining unoccupied fertile lands it is apparent that through the latter of these methods will soon lie the only hope of accomplishment of the end sought.

The methods of farming or soil management and the adaptation of crops must be varied to suit the natural conditions presented by the various types of soil as well as other controlling factors in crop growth. An intensive study of soil types becomes, therefore, one of the indispensable bases on which to build a system of intensive agriculture. The attainment of a knowledge of the distribution and character of the various types of soil is a matter of prime economic importance in the development of good farming in Michigan and this is the end to be attained through a soil survey.

But a soil survey is of little value in itself unless the information which it develops is intelligently used in connection with

*An Act to Provide for the Further Geological Survey of the State.

what is known about agricultural conditions on various soil types and environments. The soil survey has been preceded and will in any event be followed continuously by studies conducted by the Agricultural Experiment Station. The establishment of soil types and the ascertainment of the distribution of the various types is not an end in itself but it is a step in general agricultural progress which may be accomplished within a short period and with finality. A soil survey should provide a permanent basis for practical application of the results of the labors of the agricultural experiment stations for the continuous prosecution of which the government has provided.

The investigations of the Geological Survey are so far advanced that we have been able to issue a reconnaissance soil map of the state together with descriptive texts of a general nature. Judging from the demand for these maps, which has now risen to a hundred thousand copies, it is apparent that this work has, in a measure, filled an important need for information regarding Michigan soils. It is a permanent and substantial accomplishment and will not be entirely superceded by the more detailed work now under consideration. These maps express admirably the *general facts* of the nature and distribution of Michigan soils, and the need for information in this form will always exist. But general or reconnaissance soil study and mapping is quite inadequate for the more important and special purposes above considered.

Organization of a Soil Survey. I will not here go into details regarding the most efficient organization of a soil survey but will state briefly the more important matters which should be considered in any plan which might be adopted. The mapping of soils is a work which must be considered from the double view point of the geologist and agriculturist. It is therefore important that the field worker combine both geologic and agricultural training and experience. If the soil survey were undertaken on a considerable scale at once some difficulty would be experienced in the beginning in acquiring a field force properly trained for the work. A permanent laboratory equipment such as now exists at the Agricultural College Experiment Station would be essential to a soil survey. It would seem, therefore, that a soil survey of Michigan should combine the facilities of the Geological Survey and the Agricultural College in some plan of co-operation.

Any plan for a soil survey of Michigan should provide for the acceptance of such co-operation as may be offered by counties, development bureaus or societies, boards of commerce and the United

States Bureau of Soils. It is probable that legislative appropriations for a soil survey would be considerably augmented by contributions from some of these sources, especially from the United States Bureau of Soils, which under certain conditions of co-operation will agree to meet half the cost of the whole work.

A question of first importance in consideration of a plan for a soil survey refers to the cost. On this point it should be stated at once that a soil survey in Michigan will be relatively more expensive than in many other states where soil types are less in number and simpler in relationship and distribution. There are no purely residual soils in Michigan, in fact the soil formations in most parts of the state bear little relationship to the underlying hard rocks. The various Michigan soil types have their origin in depositional processes resulting directly and indirectly from glaciation. There are large areas of exposed Glacial-Great-Lakes bottoms, chiefly fringing the two peninsulas, but most of the remainder of the soil formations were glacially or fluvio-glacially deposited and exhibit the wide diversity of types and the complexity of distribution characteristic of such formations. The cost will also be influenced by the relative state of development of the different parts of the state and the availability of good base maps such as those being made by the topographic survey. Wherever possible the topographic survey should precede the soil survey for such procedure will not only save money but the resulting soil maps will be much more useful. Elsewhere in this report I have discussed the importance of topographic maps to a soil survey. From experience in other states under similar conditions it would seem, all things considered, that the total cost of a soil survey in Michigan should not exceed \$3.00 per square mile, not including cost of publication, in the developed portions, and in the undeveloped parts considerably more, probably as much as \$4.00 per square mile. A soil survey of Ingham county, for instance, should not exceed \$1,700.00 or about 4½ to 5 cents per acre.

Recommendations. After a thorough consideration of the subject extending over a period of five years and after a sufficient lapse of time for appreciation of the value of the preliminary soil survey which has already been accomplished I am convinced that a thorough study, classification and mapping of Michigan soils should be undertaken on a plan sufficiently comprehensive to insure rapid progress to completion. I estimate the cost of the entire work at \$200,000.00 and believe that an appropriation of half this amount by the state at the rate of \$10,000.00 per annum

would, with the co-operation of the United States Bureau of Soils and possibly other organizations within the state, insure its completion in not to exceed ten years. The importance of a soil survey to the development of agriculture warrants the serious consideration of this measure by the Board of Geological Survey and the legislature.

RELATIVE TO REGULATION OF THE DRILLING AND CARE OF DEEP WELLS.

In my last biennial report I called attention to the advisability of making effective legislative provisions against the harmful results of unregulated deep drilling. A bill embodying the recommendation therein made received favorable consideration by committees in both houses of the legislature, passed the senate, but was still in the hands of the *ways and means committee* of the House at the close of the session. During the past two years this subject has been further studied and was discussed at some length by Mr. R. A. Smith in Publication 14, Geological Series 11, pages 247-54.

In view of the importance of the regulation of deep drilling in Michigan permit me to again urge this matter for further consideration by the legislature. As an aid to a proper appreciation of the need of effective regulation of deep drilling and the proper handling of abandoned deep wells I introduce here Mr. Smith's discussion and suggest the terms of a bill which seem most nearly to meet the requirements of this situation.

"The Regulation of Drillings and Care of Deep Borings. In all oil and gas fields a larger or smaller percent of the wells drilled are dry holes or holes with a yield which is too small for profitable operation. In "spotted" fields, such as in Randolph county, Indiana, 40 per cent of the wells may be dry. In many fields, such wells are abandoned without plugging with the result that water, which is generally encountered at one or more horizons, makes its way into the oil and gas sands with disastrous consequences. Sometimes the casings are left in the wells but this is only a temporary protection as the corrosive action of the brines or mineral waters generally will destroy ordinary casings in two to five years.

Most oil and gas bodies are surrounded by salt water but this water, known as "edge water" invades the reservoirs only as the oil and gas are withdrawn (providing these products are not withdrawn at too rapid a rate), so that a maximum recovery is possible. When water is introduced directly into the productive portion of a field through an uncased, or improperly cased well, the oil is forced back into the sand, so that pumping may produce nothing but water. As the sheet of advancing water reaches other

wells, their production becomes partly, or entirely water, and the final result will be the ruin of the entire field.

In the older oil and gas fields of the country, little or no attention was given to abandoned and unplugged wells and the life of many pools has been greatly shortened or abruptly terminated by the flooding of the sands by water. In California¹, investigations by the State Mining Bureau have disclosed the fact that the productivity and life of many of the oil fields of that state are menaced by water from improperly cased and unplugged wells. Reports obtained from 41 per cent of all the wells in operation show that 25 per cent of these wells produced from 10 to 50 percent or over of water. Similar menacing conditions exist in most of the fields of the country, and had proper means and methods been used in the drilling and care of wells, these conditions could have been largely avoided.

Abandoned or improperly cased wells are not only a menace to productive wells in an oil and gas field, but they are a source of pollution to potable waters or valuable brines and mineral waters. Brines or mineralized waters from one horizon may invade another containing fresh water, or, vice versa, fresh water may find ingress to brine bearing or mineral water strata. In the first case, supplies of potable water, the most valuable of the natural resources, are destroyed and, in the second, the quality of the brines or mineral waters is injured or ruined.

Along Saginaw river, most of the former supplies of fresh water in the surface deposits have been ruined through leakage from the abandoned salt wells unplugged or improperly plugged. In the vicinity of Grand Rapids drillings for salt and gypsum have permitted the sulphate brines of the Michigan Series to percolate down into the underlying Marshall, and, locally, the former supplies of fresh water in this formation have been destroyed. As these old test holes and many others scattered over the state are still unplugged, the injury to valuable supplies of brine and fresh water grows greater from year to year. The above cases are not exceptional but are rather typical of conditions obtaining in many portions of the country.

Many oil and gas fields are located in coal fields; particularly is this the case in Pennsylvania, West Virginia, Ohio, Indiana, Illinois, Kansas and Oklahoma. Oil and gas wells penetrating workable coal seams or active mines add greatly to the hazards of mining on account of the danger of the escape of gas or oil into

¹R. P. McLaughlin, Preliminary Reports on Petroleum. Nos. 1 and 2, Cal. State Mng. Bur. 1914.

the mines with the consequent danger of explosion. The casings may be improperly placed, breached by the corrosive action of brine or mineral water, broken by the caving or subsidence of the overlying strata subsequent to the mining of the coal, or removed upon abandonment of the wells. In several instances, severe explosions of natural gas from this source have occurred in coal mines, and many others have been narrowly averted.

In Pennsylvania, there are over 50,000 oil and gas wells in coal territory, and it is estimated that 3,000 new wells are drilled each year, 2,000 of which are abandoned. Most of the latter are abandoned without being properly plugged or charted. Many of those though not producing commercial quantities of gas, yield enough to cause explosions and fires, if it were to leak into a mine. In some localities, the oil and gas wells are so numerous and close together that they not only seriously interfere with mining operations but cause much loss of coal through the large pillars which must be left to protect the wells. Owing to the close drilling and the number of unplugged and uncharted wells the leases on certain coal properties in Pennsylvania have been surrendered on the ground that the estimated recovery of coal is too small and the hazards too great to pay for mining. In addition to the danger from gas and the loss of coal noted above, water from unplugged and uncharted wells may flood the mine workings. This has happened in a number of cases. Water, under a head of 400 feet, broke into two mines in Illinois in 1912 and caused much trouble and expense before it was controlled.

Since many of the older oil and gas fields have been redrilled from one to three times and tens of thousands of holes are being drilled in coal territory, hitherto unprospected for oil and gas, the situation between the coal and the oil operators has become acute. A number of states have passed laws with the aim of protecting and conserving the oil and gas resources, but only in Ohio, Indiana, and Illinois have measures been enacted to protect the coal mines and coal reserves from the dangers of the promiscuous drilling of oil and gas wells. The laws, however, in all of these states are inadequate.

On the other hand, mining operations are a menace to the oil and gas wells. As noted previously, the slumping of the strata after the removal of the coal or other minerals may bend or break the casings and ruin some of the wells. The broken casings in the case of abandoned mines also permit the entrance of water to the sands with consequent injury to the field.

As a result of these conflicting interests, a bitter antagonism has grown up between the coal and the oil and gas operators. Manufacturing concerns utilizing brines and mineral waters also look with disfavor upon drillings which endanger the purity and strength of their supply of these substances.

It is most regrettable, that in the past the public at large has displayed only an apathetic interest in the conservation of the potable water supplies. Owing to the wave of agitation for the conservation of the natural resources which has swept over the country during the past few years, strong efforts have been made in many states to secure adequate laws regulating the drilling and care of deep borings, more particularly those for oil and gas. In certain states, opposition on the part of the oil and gas interests has been successful in defeating every attempt at securing much needed legislation on this subject. Oklahoma, California, Wyoming, Illinois, and a number of other states, however, have passed remedial and protective measures. Unfortunately, in some states, the measures are rendered almost nugatory through failure to provide for proper administrative machinery, sufficient funds, or adequate penalties for violations of the law.

In Pennsylvania and West Virginia, the law requires that abandoned wells must be plugged, but there is no competent executive officer to see that the requirements of the law are properly complied with. In Ohio, owners of wells must notify the Salt Mine Inspector ten days prior to the contemplated abandonment of a well so that, at his discretion, he may notify a district mine inspector to be present when the well is plugged. A man may be an efficient mine inspector but incompetent to supervise the plugging of an oil or gas well. Moreover, mine inspectors, beyond the protection of the coal mines have little interest in the protection of oil and gas sands or water and brine horizons. In the California laws, there is no provision for a central executive authority. The drilling and care of wells is left to the county well commissioner, who is appointed at the request of three or more oil companies operating in the county. The Indiana laws of 1903 require owners upon the abandonment of a well to plug the same according to certain specifications and file an affidavit signed by two witnesses, describing in detail the manner in which the well was plugged. Since the law does not require that the State Natural Gas Supervisor shall be notified, this official has no means of knowing when a well is to be plugged or when the law has been violated, except through information furnished by outside parties. "Fly-by-

night" operators take advantage of this, "pull" their casings, and seek more promising fields in other states without plugging their wells.

In Wyoming, the laws prohibit the waste of oil or gas from a well beyond a limit of thirty days, specify the manner in which wells shall be plugged, and provide penalties and liabilities, but there is no central authority to enforce the provisions of the law. No legal action is taken except on the formal complaint of an interested party.

The Illinois statutes provide that all fresh water, during the drilling and after the completion of a well, shall be kept cased off from the oil and gas sands, in addition to the requirement that abandoned wells shall be plugged. The law fails of its purpose as there is no provision for adequate administrative machinery. The only protective measure in Michigan is a law requiring that, in Saginaw and Bay counties alone, salt wells shall be plugged upon abandonment. In short, in none of the states do the existing laws relative to the regulation of the drilling and care of oil and gas wells secure the desired ends.

In order to fully protect the rights of all parties concerned, a law regulating the drilling and care of oil and gas wells or other deep borings must provide for, (1) a competent administrative body having adequate executive powers, sufficient funds and trained assistants to properly carry out the provisions of the law; (2) definite methods of (a) casing and protecting wells through beds of coal, clay or other mineral deposits, and through horizons bearing valuable brine and mineral or potable water and, (b) of plugging wells, (3) the collection and filing of all information bearing on the geologic conditions, i. e., the character, thickness, and depth of the various formations, the water and the oil and gas horizons, (4) the formal and accurate (a) location and recording and (b) the formal abandonment, plugging, and inspection of wells; (5) the co-operation of all parties concerned; and (6) adequate penalties and liabilities for infractions of the law and for damages.

The chief difficulties in framing a workable and satisfactory law regulating the drilling and care of oil and gas or other deep borings arises from (1) the conflicting interests and (2) the variety of conditions which may be met. A law which will adequately protect the coal operator and minable coal beds may work undue hardship upon the oil and gas prospector. In some districts, there are several coal seams, some of which are of workable thickness

under present conditions and others not. The term "workable" thickness is a relative one. Whether a coal bed is workable or not depends upon several factors besides that of mere thickness, viz., quality of coal, mining and labor conditions, nearness to markets, and competition. In Wales, veins of coal under 14 inches in thickness and in Missouri and Kansas beds 12 to 20 inches thick are operated at a profit, while in some coal fields no beds under four feet thick are being mined. With further exhaustion of the coal reserves, or with the development of new market or cheaper methods of mining, some of the beds too thin to mine now may become workable.

The churn or percussion drill is generally used for oil and gas explorations, and, with this type of drill, it is very difficult to determine the exact thickness of coal beds and many drillers pass through workable beds without recognizing their presence. In Michigan, there are a dozen or more seams of coal, extremely variable in thickness and extent. Apparently only a few of the beds contain areas thick enough to be mined under present conditions, and these areas are very local. From this, it follows that there is no absolute way of distinguishing the different seams of coal, and it would be impossible in many cases to determine what seams should be protected. To require a driller to case off and protect each coal bed encountered would not only entail prohibitive expense, but it would be practically impossible in many cases on account of the size of the hole which would be required. The same may be said of the water and brine horizons, since, in some regions, there are a number of water or brine horizons, each yielding a water or brine differing in quality from any of the others.

The capping of oil and gas wells within a definite time limit to prevent waste may be very difficult or even impossible as in the case of the great oil wells in the eastern Mexico fields and the gas wells of Texas and Louisiana. It cost \$3,000,000 to put out the fire and cap the great DosBocas well No. 2 near Tampico. In many instances, the plugging of a gas well too small to be operated is very difficult, especially where the rock pressure is very high, and it may cost several thousand dollars. To case off the salt water which occurs between the two productive oil sands in the Midway-Sunset field of California costs about \$10,000 additional per well, yet it must be done to protect the oil sands.

The designation of a specific method for the casing and plugging of wells is unsatisfactory as no one method is adequate to meet the different conditions which may be encountered in different parts of

a state, or even in the same field. A given method may secure the desired results in one case, but may fail of its purpose in another. Two or more efficacious methods, however, may be outlined to meet the conditions more commonly occurring, but certain discretionary powers as to what coal beds and water and brine horizons shall be protected, and what method and means are to be used in a particular case, should be given the administrative official or body, but arbitrary power over the casing and plugging of wells should not be placed in the hands of a single individual.

One of the greatest difficulties in intelligently applying the remedial and protective measures of a law lies in the lack of an organized body of information concerning the character, thickness and depth of (1) the formations, (2) the oil and gas horizons and, (3) coal beds or deposits of other minerals and mineral substances having present or possible future value. In some fields where the sands are little disturbed, regular in thickness and character and continuous over large areas, the problem of drilling and caring for wells is comparatively simple, but in fields where the sands are numerous, variable in character, discontinuous and much disturbed, and where there are several water bearing strata, some of which lie between the productive sands, the problem demands the fullest knowledge of the geological conditions and taxes the ingenuity of the most highly trained geologist-engineer.

The usual penalties prescribed in the laws of the several states are nominal fines from \$100.00 to \$500.00, or both fines and imprisonment. In those states where the maximum fine is but \$500.00 and the cost of repairing the casing of a well or of plugging a well is several thousand dollars the fine is ridiculously small in comparison. To obviate this difficulty some states have made the fine cumulative according to the length of time that the offender fails to comply with the requirements of the law.

For many years the drilling and care of oil and gas wells has been the subject of much study and investigation. During the past few years the United States Bureau of Mines has made an exhaustive study of this subject with special reference to the danger of life and property from drillings for oil and gas in coal territory. In order to secure information bearing on every aspect of the subject, the Bureau of Mines has been in the practice of conferring from time to time with students of the subject and representatives of all interest concerned. The information has been collected with the view of formulating and recommending changes in the present practices in the drilling and care of wells, and also

changes in the state laws which might prove effective by being "both reasonable and enforceable." As a result of these separate conferences, a general conference² was held February 7 and 8, 1913, between representatives of the coal operators, the oil and gas companies, the geological surveys of the various states, and the Bureau of Mines of the United States. At this conference, problems, arising particularly from the interrelations of oil and gas wells and coal mines, and tentative suggestions for the legal regulation of drillings in coal regions, were discussed at length. The tentative regulations were referred to a committee of twenty composed of three representatives from each of the interests: coal, natural gas, petroleum, state geologists, state mine inspectors, and the Bureau of Mines, together with the president and secretary of the conference. This committee met on March 1 and 10 and made a revision of the proposed regulations, which was presented to the general conference on March 11. The proposed regulations as drafted by this conference are in the form of an outline³ of desirable legislation, to be developed in proper legal form to meet the industrial needs of each state.

The essential features prescribed in the proposed regulations are six in number, viz:

- (1) Accurate and formal location and recording of wells.
- (2) Co-operation of the several parties interested to obtain a safe location.
- (3) Designation of efficacious methods of casing and protecting wells through coal beds.
- (4) Formal abandonment of wells.
- (5) Safe methods of plugging wells.
- (6) Adequate inspection.

The proposed measure placed the administrative power in the hands of a single individual, the Chief Well Inspector of the state, and this is one of the objections strongly urged against it. According to R. P. McLaughlin of the State Mining Bureau of California, experience has shown that the arbitrary power to order repairs or the abandonment of a well should not be wielded by a single individual. Other investigators hold that the control of drilling and plugging of wells should be in the hands of a commission composed of the State Geologist, the head of the State Mining Board or Inspector of Mines, and a third member chosen from the oil and gas operators. A second criticism refers to the framing of specific

²Bull. No. 65, U. S. Bureau of Mines, Oil and Gas Wells through Workable Coal Beds, 1913.

³Technical Paper No. 53, U. S. Bureau of Mines. Proposed Regulations for the Drilling of Gas and Oil Wells. O. P. Hood and G. Heggen.

regulatory measures designed to protect coal mines and coal reserves without adequate protection of potable waters, valuable brines and mineral waters, deposits of clay, gypsum, limestone, shale, or other minerals or mineral substances. A third criticism may be made as to the lack of explicitness regarding the control of the chief oil and gas inspector over the kind of geologic records to be kept of each drilling. This is most necessary to the intelligent application of the remedial and protective provisions of the law, and the information contained in a log made by the average driller is far from reliable. The Chief Well Inspector should have power to prescribe the kind of record to be kept and to demand, as circumstances warrant, sets of samples of the well drillings and samples of the waters and brines encountered.

In 1912-13, the Saginaw Development Company drilled a number of wells for oil in close proximity to the salt wells in Saginaw and the operators of salt blocks were alarmed lest these borings should be abandoned without being properly plugged. The law requires that only those wells drilled for salt in Saginaw and Bay counties alone must be plugged, hence the Development Company was not legally bound to plug their borings upon abandonment. The company, however, of their own accord plugged all their wells which were near enough to contaminate the brines utilized by the salt blocks along Saginaw river."

In order to arrest economic loss and guard against the other harmful results of unregulated promiscuous deep boring in Michigan an attempt was made during the last session of the legislature to enact a general law regulating the boring and care of deep wells and providing for adequate plugging of these wells on abandonment but the bill, after passing the Senate, was permitted to languish in the house Committee on ways and means.

This is not a new subject of legislation; the legislature has attempted to deal with it from time to time and two measures have resulted, both of which are ineffective, have never been enforced and even if they were enforced would still be inadequate to meet the situation. Both of these laws should be repealed even if nothing further is done. Sections 5480, 5481 and 5482, compiled laws of Michigan, 1897, seek to secure and regulate the plugging of salt wells in the counties of Bay and Saginaw. The administration of the law is charged to the State Salt Inspector, whose office was abolished by the legislature two years ago. Sections 5673, 5674 and 5675, compiled laws of 1897, seek to prevent waste of artesian water but the means which it provides for effecting its

purpose are weak and wholly inadequate. The effect of the law is therefore nil and it should be repealed.

I present below the text of a bill which is the result of very careful consideration of the experience of all the other states and expresses the consensus of the best opinion in this country. I present the recommendations in the form of a bill merely for convenience and as a basis for consideration of the whole subject by the legislature.

A BILL

To provide for the location, drilling, casing, protecting, operating, abandoning, plugging and filling of oil, gas, and brine wells, and for the protection and preservation of property connected therewith and for the preservation of life, especially in and about coal mines in gas and oil regions and creating a Well Commission:

The People of the State of Michigan enact:

CHAPTER I.

Definitions.

SECTION 1. That for the purposes of this Act, the terms and definitions contained therein shall be as follows:

Well:—A hole drilled for the purpose of discovering or developing oil, gas, brine or water or a hole producing oil, gas, brine or water.

Well Operator:—Any person, persons, firm, partnership, corporation, company, etc., who drills, operates or abandons, or purposes to drill, operate or abandon a well or wells as hereinbefore defined.

Coal Operator:—Any person, persons, firm, partnership, corporation, company, etc., engaged in mining or producing coal, owning, leasing or operating coal mines or coal properties.

Plat:—A map, drawing or print made in accordance with the provisions of this Act.

Casing:—A pipe commonly used within wells drilled for oil, gas, brine and water.

Cement Mortar:—Cement mortar shall consist of one part of Portland cement and two parts of clean sand mixed with water.

Well Commission:—The Commission as herein provided shall consist of the State Geologist and the Public Domain Commission.

Area of the state to which this Act applies:—That part of the surface area of the state of Michigan which is underlain by rocks of Palaeozoic age, as defined on the maps of the Geological Survey of Michigan.

CHAPTER II.

Location of well and license of well operator.

SECTION 1. It shall be unlawful for any person, persons, firm, partnership, company, corporation or other interests, to drill, bore or sink any well to a depth greater than 100 feet, measured vertically from the surface of the ground, for the purpose of discovering or producing salt or salt brines, mineral waters or other waters, oil, gas, gypsum, limestone, shale, coal or other mineral products or for any other purpose in that part of

the state which is underlain by rocks of Palaeozoic age without having first obtained a license from the Well Commission.

SECTION 2. When the location for a well has been made it shall be the duty of the well operator to make application in writing to the Well Commission for permission to drill and to send therewith a description and plat in duplicate of the proposed location. The location shall be determined by survey and the description and plat shall give the course and distance from two permanent points on the boundaries of the property upon which the well is located, together with the name of the property, names of adjoining tracts, sections, lots, streets, township, county, etc. It shall also be the duty of the well operator to send to the coal operator, if known, and on request of the Well Commission, to the State Coal Mine Inspector a copy of the description and plat filed with the Well Commission. It shall be the duty of said coal operator immediately upon receipt of the plat to verify the well location and mail to the well operator a plat showing the present and proposed mine workings, if any, under said property.

If, after the expiration of five days (excluding legal holidays) after said plat has been received by the Well Commission no notice of complaint shall have been received by the Well Commission a license shall be issued without further delay.

If notice of complaint is served on the Well Commission within said five days then it shall be the duty of the Well Commission or their authorized deputy to confer with the several interests including the State Coal Mine Inspector, coal operator and well operator and after hearing the several interested parties, if a formal hearing is demanded, shall designate within fifteen days of the receipt of the application for license a suitable location for the well or refuse to issue license to drill.

After the well is relocated a re-survey shall be made by the well operator and corrected description and plat mailed as previously required.

It shall be the duty of any coal operator to furnish annually to the Well Commission a plat of all of its present and proposed mining operations within the state. The coal operator shall also furnish if requested, to any well operator, a plat of the mine under the leases or property owned or operated by said well operator.

SECTION 2. Distance from buildings. No oil or gas well drilled under the provisions of this Act shall be located within 300 feet of a hoisting or air shaft, slope or drift into a coal mine not definitely abandoned or sealed, nor shall such well be located within three hundred feet of any mine shaft house, boiler house, engine house, power house, mine fan or mine tippie, unless such structures have been abandoned. No such well shall be located within fifteen feet of any mine haulage way or air way in use.

SECTION 3. It shall be the duty of the Well Commission to issue a license in duplicate and the well operator shall display at the location one copy of the license, properly protected from injury and in such place and manner as may be easily seen.

SECTION 4. It shall be the duty of the Well Commission to furnish on request of any applicant all such printed forms, blank forms, etc., as it may deem necessary in properly executing the provisions of this Act.

CHAPTER III.

SECTION 1. Each well drilled through a workable seam of coal shall be drilled, cased and protected in the manner hereinafter provided:

(a) - Where the coal is in place.

A hole of a diameter of six inches greater than the size of the outside casing to be put through the coal shall be drilled at least thirty feet below the bottom of said coal seam.

Within this hole shall be placed the casing, and the space between the outside of said casing and the hole shall be filled with cement mortar, or puddled clay, to a height of at least thirty feet above the top of said coal seam, and in such manner as to exclude water from the coal seam.

(b) Where the coal is removed and the mine excavation is inaccessible.

A hole of a diameter sufficiently large to permit the setting of a liner four inches larger in diameter than the casing to be put through the coal, shall be drilled at least thirty feet below the bottom of said coal seam.

Within this hole shall be placed a liner four inches larger than the said casing and extending from the bottom of said hole to at least thirty feet above the mine roof.

A string of casing centrally guided by shoes or winged guides shall be laced within the said liner and the space between the liner and the casing shall be filled with cement mortar or puddled clay to the top of the liner.

To exclude water, the space between the said casing and the wall of the hole and immediately above the top of the liner, shall be filled up a distance of at least ten feet with cement mortar or puddled clay.

(c) Where the coal is removed and the mine excavation is accessible.

The method may be either as provided in the case of inaccessible mine excavations or as where the coal is in place, provided; that if the latter method is chosen the well operator shall at his own expense provide a suitable retaining wall laid in cement mortar to retain the cement mortar or puddled clay about the casing. This wall shall extend from two feet below the mine floor to the roof of the mine, and be of such size as to retain at least two inches of puddled clay or cement mortar about the said casing.

Under any of the above provisions the work of casing and protecting from gas and water through the coal seam shall be completed, if possible, before the well is drilled to a greater depth; and in the event of any well being productive of oil or gas, the space between the said outside casing and the next string of such other casing as may be left in, shall remain open at the surface for proper ventilation, the top being provided with a suitable device to permit such ventilation and at the same time to prevent dirt or debris from falling in, or being thrown in, or the ventilating opening from being readily closed.

CHAPTER IV.

SECTION 1. It shall be the duty of the owner of any well that may be drilled in the state of Michigan on lands producing or containing oil, gas or salt brines or other mineral waters to properly case such well or wells in accordance with the most approved methods and to effectually shut off, and confine if necessary by the use of packers or cement outside of the casing, all water overlying and underlying each oil bearing and each gas bearing and each coal bearing and each brine bearing stratum and each stratum bearing other mineral waters and in such manner as will effectually confine the brine, mineral waters, oil and gas to the stratum or strata in which they naturally occur.

CHAPTER V.

SECTION 1. Any person, firm or corporation drilling, boring or sinking any well, drill hole or other opening to a depth of more than one hundred feet as provided in Section 1, Chapter II, shall be required to keep a careful log or record showing from the surface of the ground to the bottom of the hole the character, thickness and depths of the various rock formations penetrated and particularly the location and thickness of each formation bearing water, fresh or salt or brackish or mineralized, oil or gas and the location and thickness of each bed of coal, gypsum, and limestone and shall on written request of the Well Commission file with the Well Commission a true copy of such log or record and shall also be required further on written request of the Well Commission to secure and preserve samples from each and every five feet of the rock material penetrated and to deposit such samples in the office of the Geological Survey of Michigan.

CHAPTER VI.

SECTION 1. It shall be unlawful for any person, persons, firm, company or corporation having possession or control of any natural gas, oil or brine well, whether as a contractor, owner, lessee, agent or manager to allow or permit the flow of gas, oil or brine from any such well to escape into the open air, without being confined within such well or proper pipes, or other safe receptacle for a longer period than thirty days next after gas, oil or brine shall have been struck in such well, and thereafter all such oil, gas or brine shall be safely and securely confined in such well, pipes or other safe and proper receptacles. Relief from the provisions of this chapter may in certain cases and on written request be granted as the judgment and discretion of the Well Commission may elect.

CHAPTER VII.

Abandonment.

SECTION 1. It shall be the duty of the well operator upon determining to abandon any well to send notice in writing to the Well Commission of his intention so to do and the work of plugging the hole or pulling the casing shall not proceed until the Inspector shall be present to see that said plugging is done as prescribed by this Act, except as hereinafter provided.

In case the authorized deputy of the Well Commission fails to be present within five days from receipt of notice then the work may proceed, provided that three men having experience of at least three years in the plugging of wells be present and make affidavit in duplicate that work was done in accordance with the provisions of this Act, said affidavits to be filed with the Well Commission and made a record of their office.

It shall be the duty of the well operator to send to the Chief Inspector with the notice of abandonment, a certified copy of the license to drill said well, provided the well was drilled under the provisions of this Act.

If the well was drilled prior to the passage of this Act, it shall be the duty of the well operator to send to the Chief Inspector, with the notice of abandonment, a plat showing the location as herein provided for locating a well in the application for license to drill.

When the work of plugging and filling from bottom to top has been completed, it shall be the duty of the well operator, or his authorized agent, to make a report in duplicate to the Well Commission, upon forms to be furnished him, showing the date of completion of the work, the depth of the coal seam, if any, and the total depth of well.

He shall also report if the well had, previous to abandonment, been productive of oil or gas, and if so, the name and depth of the productive measure or measures.

He shall also report the location of and kind of all plugs used, and the method followed in placing same; also the material used and method followed in filling well.

In case the Chief Inspector or his authorized deputy has not been present, this report shall be joined in by three men employed on the work as provided for in this Act.

CHAPTER VIII.

Well Commission: Creation of and duties.

SECTION 1. There is hereby created a Commission to be known as the Well Commission which shall consist of the members of the Public Domain Commission and the State Geologist. The Well Commission shall elect one of its members as Secretary who shall be the executive officer of the Commission. The members of the Well Commission shall serve without salary, but shall be reimbursed from funds herein provided, on warrant of the Auditor General, for such actual and necessary expenses as may be incurred in the performance of the duties imposed upon them by this Act.

SECTION 2. Chief Well Inspector. Duties of, etc.

The Well Commission shall appoint one assistant who shall be known as the Chief Well Inspector, and whose salary shall not exceed \$..... per annum, and such others as may from time to time be necessary to execute the provisions of this Act.

The Chief Well Inspector shall, before entering upon the discharge of his duties, give bond in the sum of \$..... with approved surety or sureties for the faithful discharge of his duties; and shall take oath that he will discharge the duties with impartiality and fidelity to the best of his knowledge and ability. But no person who is acting as manager or agent of any oil or gas company, or any coal company, or who is interested in operating any oil or gas well or any coal mine, shall at the same time act as Chief Inspector under this Act.

It shall be the duty of the Chief Well Inspector to carry out all of the provisions of this Act, and keep a complete record and prepare for publication, a yearly report of the wells drilled in the state, together with their location, date of completion, depth, production, date of abandonment, and name of owner and other information.

The Inspector shall receive and investigate all complaints as to injury, present or impending, due to lack of precaution on the part of the well owner or coal mine operator. If he finds the complaints against the coal mine owner to be well founded, he shall lay the facts before the State Coal Mine Inspector.

In case of failure of the owner to properly plug an abandoned well, it shall be the duty of the Inspector to have the work properly performed by contract, and to assess the cost against the well owner. In case the well owner shall refuse or neglect to pay the cost and expense of plugging an abandoned well within thirty days after being notified by the Chief Inspector so to do, said official shall begin an action of assumpsit against said owner to collect said expense, as in other cases now provided by law.

If the Inspector discovers any well being drilled, operated or plugged, contrary to the requirements of this Act, he shall order the workmen engaged on such well to cease work at once, and shall not permit the work to be resumed until he is satisfied that the law is complied with.

To enable the Inspector to perform the duties imposed upon him by this Act, he shall have the right at all times to approach and examine any well and with the authority of the State Coal Mine Inspector, to enter any coal mine affected, and upon discovery of any violation of this article or upon being informed of such violation, he shall institute proceedings against the person or persons at fault, under the provisions of the law provided for such cases.

The Inspector shall determine the sufficiency of plats for the purpose of accurately locating wells, and shall cause a new survey of such location in case the available plat and description are unsatisfactory.

This survey shall be paid for by the applicant unless it is shown that the original plat is correct, in which case the cost is to be borne by the state.

CHAPTER IX.

Any coal operator or well operator who neglects or refuses to comply with the provisions of this Act, or who violates any of the provisions or requirements thereof, shall be deemed guilty of a misdemeanor, and shall, upon conviction thereof before any court of competent jurisdiction in the county in which the misdemeanor was committed, be punished by a fine of not less than \$..... or more than \$....., or by imprisonment in the county jail not to exceed days or by both such fine and imprisonment in the discretion of the court.

CHAPTER X.

SECTION 1. Whenever any person, firm, company or corporation in possession or control of any well in which natural gas, oil, salt brines or other mineral waters have been found shall fail to comply with the provisions of

this Act, any person, firm, company or corporation lawfully in possession of lands situated adjacent to or in the vicinity or neighborhood of such well may enter upon the lands upon which such well is situated and take possession of such well (for the purpose of this section only) from which oil, gas, salt brines or other waters are allowed to escape into the open air or into any other stratum or strata of rock than that in which they naturally occur in violation of the provisions of Section one, Chapter VI, of this Act, and pack and tube such well, and shut in and secure the flow of gas, oil, salt brines or other mineral waters and maintain in a civil action in any court of competent jurisdiction in this state against the owner, lessee, agent or manager of said well and each of them jointly and severally, to recover the cost and expense of such tubing and packing, together with the costs of suit.

Provided that such person, firm, company or corporation shall first notify the Well Commission of the time when it will pack and tube such well, in order that he may, if deemed necessary, direct the method in which such packing or tubing shall be done.

CHAPTER XI.

All acts or parts of acts in conflict herewith are hereby repealed.

CHAPTER XII.

SECTION 1. To carry into effect the provisions of this Act, the sum of dollars for each year is hereby appropriated to be drawn from the treasury as needed.

**CONCERNING THE RELATION OF THE GEOLOGICAL AND
BIOLOGICAL SURVEY TO THE CONSERVATION OF
THE ANIMALS OF THE STATE.**

The biological work of the Survey is overlooked in the matter of legislation affecting the game life of the state. Therein lies a failure to make a logical and useful adaptation of its work. On this important matter I can do no better than quote from an address on the topic by Dr. Ruthven before the joint conference held under the auspices of the Public Domain Commission in Lansing, June 12, 1912.

"It is apparently not generally known that the biological division of the survey has for the past seven years been engaged in a careful study of the animals of Michigan. The ground covered by this work may be judged when I say that enough information has now accumulated to permit us to give expert advice on such subjects as what species are found in particular parts of the State, what areas are best for preserves, which forms are harmful to the farmer and which beneficial or harmless, the local abundance and habits of the different animals, etc. This data is freely used by teachers and scientists, but it is not used by those who draft our game laws.

Beyond question such information is needed. The farmers in particular parts of the state know some of the obnoxious and beneficial animals, and the sportsmen know some of the game animals that need protection in their vicinity, but the knowledge of the best of these men is rather closely limited not only to the particular class of animals in which they are interested but also to the more conspicuous forms and generally does not extend to a knowledge of habits; the whole subject is complicated by those who wish to protect, for aesthetic reasons, all but the most obnoxious of our animals. It goes without saying that the interests of all these persons must be considered, but this cannot be done when any one of them may introduce and put through laws embodying their ideas, for, as I have intimated, no one of them is, as a rule, in a position to give the matter thorough study. This is coming to be generally recognized. The northern Michigan sportsmen declare that the southern Michigan sportsmen cannot legislate for their area, the southern Michigan sportsmen believe that they are the

best judges of the laws needed for their region, and I believe that it is not too much to say that not one farmer out of five has an accurate knowledge of the habits and economic importance of the animals found on his own property. The result is that our laws are woefully inadequate in that over the state as a whole slaughter dominates natural increase. In other words, in spite of what has been done to prevent it, we still continue to kill the geese that lay the golden eggs.

It has been suggested that a census be taken of the opinion of the residents of the different parts of the state and these opinions combined into a general law. I do not wish to disparage any such laudable attempt to obtain efficient legislation, but I must say that such a procedure would be very laborious and in my opinion, while it might better conditions, the results would still fall far short of the ideal, owing to the general ignorance of the actual conditions that I have asserted exists, particularly among the farmers and the sportsmen with limited experience. I believe that I am not wrong when I say that absolutely the only way to have efficient laws regarding the animals of Michigan is to subject them to the criticism of those persons who have made a detailed study of the conditions in different parts of the state, and are impartial in their sympathies. Is this not evidently true?

It is hardly necessary for me to say that the Survey gladly places its information at the disposal of persons interested in game conservation, but something more than this is necessary, and our suggestion covers this need. I have consulted with the federal survey people at Washington, and with many people in the state who are interested in the subject, and I find a unanimous opinion, so far as it has been expressed, that probably the best way to bring about co-operation between the Survey and the individuals, associations and the other state departments interested in the conservation of the Michigan fauna would be to have all proposed legislation affecting the animals of the state submitted to the Survey for approval or at least recommendations before coming up for action by the legislature.

Such a procedure would be exactly in line with the federal methods of dealing with these problems. It has no doubt come to your attention that it is the United States Biological Survey that is charged with the protection of the animals of the United States so far as this lies outside the authority of the different states. What more logical then than that the State Biological Survey be given a voice in the matter of state legislation?

I would like to hear this suggestion considered. I cannot see that it is revolutionary, impractical or that it will cause hardship to any individual, association or state department, and it seems to me that if we are really trying to obtain co-operation, here is the opportunity to do something in that direction that will have a real value. At any rate I would like to reiterate that without such a union of forces we cannot expect our legislation as a whole to be anything but unintelligent."

RELATIVE TO PROPOSED WORK OF THE BIOLOGICAL SURVEY.

The funds available for the work of the biological survey have never exceeded \$1,000.00 per annum until last year when a slightly greater allowance became possible. It must be conceded that the results which have been attained are very much greater than would ordinarily be accounted for by this small expenditure. This is due solely to the fact that the investigators have practically donated their time and talents. Actual expenditures for travel and subsistence only is in many cases the only compensation the Survey has been able to offer in return for the services of the biologists. Nevertheless a large amount of biological work of high character has been done, only a part of which has been published.

In order to further insure the effective progress of the biological survey of Michigan, and having in mind the meagreness of funds which have been devoted to it, a committee of the Board of Advisors consisting of the Chief Naturalist, Dr. Bryant Walker, Professors Walter B. Barrows and E. A. Bessey of the Agricultural College and Professors Jacob Reighard and F. C. Newcombe of the University of Michigan were appointed to consider and recommend the wisest policy and the best program of work consistent with economy, for a period of five years. After several months of careful consideration the committee presented the report which appears below. It is to be hoped that means will be found for executing these plans and I transmit them for your consideration with my recommendation and approval:

*Report of the Committee on Policy of the Biological Division of
the Survey, Submitted and Accepted by the Board of
Advisors on May 16, 1914.*

Gentlemen:—Your committee begs leave to submit the following report. Two meetings have been held and some correspondence carried on with a view to determining a broad and practical policy that should govern the biological investigation of the Survey.

Early in the discussions of your committee it developed that the policy to be recommended would depend to some extent upon the amount of money available for the biological work. It was

recognized that detailed economic investigations to be carried on for a period of years is a proper field for a biological survey to exploit. This work is expensive, however, and could not be made the principal field on less than twice the present appropriation. It may be said that if the appropriations were much larger this line of investigation would probably have been recommended as one of two major fields of work to receive equal attention by the biological division or even given precedence over all others. The majority of the committee was strongly of the opinion that the survey of the fauna and flora of the state should be continued, both because the data to be thus secured furnishes a broad basis for other work and because the results may be organized into various reports that would appeal to a large number of residents in the state.

Inasmuch as the continuation of the survey is believed to be of great importance, and the available funds are apparently not likely to be considerably greater in the near future, and the detailed study of large problems that would extend over a period of years would entirely exhaust the present funds or would necessitate larger appropriations, your committee is of the following opinion.

- a. That the biological division should continue the survey of the state both by regions and by groups, emphasizing the ecological method.
- b. That detailed problems should receive as much attention as is compatible with the appropriations and the continuance of the survey.
- c. That the reports should be of such a nature as to be of use to the people of the state interested in the subjects treated.
- d. That detailed monographs of groups of Michigan animals and plants should be compiled that summarize all data and in such a way as to be useful to Michigan naturalists.
- e. That popular manuals should be prepared; these manuals to treat of common or economic animals and plants and to be understandable by the beginning student or non-scientific reader.

On the basis of the policy outlined above your committee has drawn up the plan of work that appears below.

The work outlined calls for an annual expenditure of \$1,500 to be paid by contract. The plan emphasizes the survey aspect but not in the opinion of the committee too strongly, and is so arranged that numerous papers will appear besides the final reports and without cost to the Survey. The different pieces of in-

vestigation have been so arranged in the whole plan that the various lines of work carried on by the Survey will receive rather continuous attention, i. e., all but one or two lines of work will not be suppressed for a series of years.

The committee recommends that this plan be adopted with the understanding that it is tentative, and subject to change if it should develop that other men than those listed should be engaged or if conditions should favor the substitution of other pieces of work, or if the appropriations should be increased.

1915.

A survey of Michigan wood lots.....	\$500 00
A study of the phanerogamic flora of Michigan.....	200 00
A descriptive catalog of Michigan fishes.....	200 00
An investigation of the economic importance of beaver	200 00
Salary of Chief Naturalist.....	400 00
<hr/>	
Total	\$1,500 00

1916.

A survey of Michigan wood lots.....	\$500 00
A study of the phanerogamic flora of Michigan.....	200 00
A descriptive catalog of Michigan fishes.....	200 00
An investigation of the economic importance of beaver	200 00
Salary of Chief Naturalist.....	400 00
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Total	\$1,500 00

1917.

A survey of Michigan wood lots.....	\$500 00
A descriptive catalog of Michigan fishes.....	100 00
A biological survey of the region about the northern shore of Lake Michigan.....	500 00
Salary of Chief Naturalist.....	400 00
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Total	\$1,500 00

1918.

A survey of Michigan wood lots.....	\$500 00
A biological survey of the region about the northern shore of Lake Michigan.....	500 00

A monographic study of a group of insects	\$100 00
Salary of Chief Naturalist.....	400 00
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Total	\$1,500 00

1919.

A survey of Michigan wood lots.....	\$500 00
Completion of a monographic study of a group of insects	300 00
Beginning of a monograph of some group of plants....	300 00
Salary of Chief Naturalist.....	400 00
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Total	\$1,500 00

Papers that may be published during the five years under the plan proposed above.

The papers listed below are those which would naturally result from the work above outlined. The reports now in manuscript or in preparation are not included.

Detailed State Reports.

A report on the standing timber of Michigan.

A monograph on Michigan fishes.

A report on the economic importance of the beaver.

A monograph on a group of Michigan insects.

These reports should be comprehensive and scientific but couched in language that can be rather easily understood by the lay reader.

Regional Reports.

The results of a biological survey of the region north of Lake Michigan.

Two reports on the phanerogamic flora of particular regions.

These three reports are the only ones called for by the plan, but regional reports may be expected.

Miscellaneous Papers.

These cannot be listed, but a large number may be anticipated. The Chief Naturalist encourages the recording of scientific data as it is discovered, and places the Survey material in the hands of specialists for study and publication. These papers are prepared and published without cost to the Survey.

Manuals.

On the proposed plan these manuals must be prepared free of cost to the Survey. This can be done in the case of a number of groups. A few manuals are suggested below, and the Chief Naturalist urges that additional suggestions be made, particularly as to manuals that the members of the committee are willing to prepare. It is pointed out that these are to be manuals rather than detailed reports.

Some common Michigan mammals and their importance.

A descriptive key to the Michigan butterflies.

A handbook of Michigan shrubs.

Respectfully submitted,

A. G. RUTHVEN,
BRYANT WALKER,
WALTER B. BARROWS,
E. A. BESSEY,
F. C. NEWCOMBE,
JACOB REIGHARD.

CATALOG AND TABLE OF CONTENTS

OF THE

PUBLICATIONS

OF THE

MICHIGAN GEOLOGICAL AND BIOLOGICAL SURVEY

1838-1914

NOTE: The greater part of the publications of the Michigan Geological and Biological Survey are distributed gratis to public libraries and exchanges, and also to citizens of Michigan on the payment of forwarding charges. A considerable number of copies of each publication are reserved for sale at the list price.

DOUGLASS HOUGHTON, State Geologist

Reports from 1838-1846 were published with Legislative documents as follows:
S. D. means Senate Document; H. D., House Document; J. D., Joint Document.
State Geologist is abbreviated S. G., and State Geological Survey, S. G. S.

- *1838. Report of a select committee of the Board of Regents of the University on the collection of the S. G.
H. D. Vol. I, p. 1-2; S. D. No. 1, p. 1. H. D. No. 55 is duplicate of No. 1. Statement of the expenditures on account of the S. G. S. for the year 1837.
H. D. No. 8, pp. 115-118; S. D. No. 21. (First annual account of the S. G.), pp. 315-318.
Report of the S. G. (first annual).
H. D. No. 24, pp. 276-317, separately, No. 14, pp. 1-39.
Communication from the S. G.
H. D. No. 46, pp. 457-460.
- *1839. Report of the S. G. in relation to the improvement of State Salt Springs.
H. D. No. 2, pp. 39-45; S. D. No. 1, pp. 1-7.
Report of the committee on the S. G.'s report in relation to the improvement of the State Salt Springs.
H. D. No. 4, p. 123.
Report of the S. G. in relation to the iron ore, etc., on the school section in town five south, range seven west, in Branch county.
H. D. No. 21, pp. 342-344.
Second annual report of the State Geologist.
H. D. No. 23, pp. 380-507; S. D. No. 12, pp. 264-391.
Report of the Committee of the Senate on Manufactures, to whom was referred the communication of the S. G. relative to salt springs and the salines of the State.
S. D. No. 3, pp. 85-86 (parallel to H. D. No. 4).
Communication from the S. G. relative to the S. G. S.
S. D. No. 25, pp. 463-466.
- *1840. Report of S. G. relative to the improvement of the salt springs.
H. D. No. 2, Vol. I, pp. 18-23; S. D. No. 8, Vol. II, pp. 153-158.
Annual report of the State Geologist (third, map of Wayne county).
H. D. No. 27, Vol. II, pp. 206-293; S. D. No. 7, Vol. II, pp. 66-153, separately No. 8, pp. 1-120.
Report of the select committee to whom was referred the several reports of the S. G.
H. D. No. 46, Vol. II, pp. 455-461.
Report of the majority of the Committee on Finance on the communication and accounts of the S. G. for 1839.
Report of the minority of the Committee on Finance on the same subject.
Report of the select committee on S. G.'s report and accounts relative to improvement of Salt Springs, etc.
S. G.'s account for the year 1839, the same being the subject matter of the three preceding reports.
S. D. No. 15, 16, 17, 18, pp. 209-224.
- *1841. Special message concerning State Salt Springs.
H., S. and J. D. No. 5, pp. 235-254.
Annual report of the S. G. (fourth).
H., S. and J. D. No. 11, pp. 472-607, separately H. D. No. 27, pp. 1-184.
Report of the S. G. relative to county state maps.
H. D. No. 35, pp. 94-98.
- *1842. Report of the S. G. relative to the State Salt Springs.
H. D. No. 2, pp. 15-21; S. D. No. 1, pp. 1-9.
Report of the select committee in relation to the report of the S. G.
H. D. No. 19, pp. 77-79.
Annual report of the S. G. (fifth).
J. D. No. 9, pp. 436-441.
- *1843. Annual report of S. G. (sixth).
J. D. No. 8, pp. 398-402.
Report of the S. G. relative to the State Salt Springs.
S. D. No. 9, pp. 402-408.

*Publication out of print.

*1844. Annual report of the S. G. (seventh).

S. D. No. 11 (three pages).

D. Houghton undertook an arrangement with the Linear Survey of the U. S. Land Office by which a certain amount of geological work was done, which was never published by the State, the results of which appear largely in the township plats of the Land Office, and in the report of C. T. Jackson, 1849, U. S. S. Ex. D. No. 1, pp. 371-935, H. Ex. D. No. 5, Vol. 3, Part 3, including sub-reports of W. A. Burt and Bela Hubbard on the geology of the sub-divisions of the Linear Survey, First Session 31st Congress, and of Foster & Whitney, U. S. Geologists, Part I, H. Ex. D. No. 69, pp. 1-224 and 12 Plates, First Session 31st Congress; S. Ex. D. No. 2, Vol. 2, p. 147, Second Session 31st Congress; Part II, S. Ex. D. No. 4, Vol. 3, p. 3, Special Session 32d Congress.

The work of the Geological Survey was interrupted by the death of D. Houghton while actively engaged in explorations.

*1846. Report from Geological Department by S. W. Higgins, principal assistant.

J. D. No. 12, 22 pp.

Report of the joint committee relative to the Geological Survey.

J. D. No. 15, 8 pages.

A. WINCHELL, State Geologist.

*First Biennial Report of the Progress of the Geological Survey, embracing observations on the geology, zoology and botany of the Lower Peninsula by A. Winchell, 1860. 339 pp. 1 geological map.

Sketch of the history of the geology of Michigan.

Part I. (a) Physical structure of the northwest and general sketch of the geology of Michigan,—the formations, their character, extent, thickness, etc.; (b) Tables of deep borings, with exhibited geology; (c) Economic geology: ores, coal, paint material, gypsum, salt, salt wells, tables of analyses, production of salt, peat, wells, and springs; (d) Physical geography, topography, hydrography, meteorology.

Part II. Catalog of the mammals, birds, reptiles, and molluscs of Michigan by M. Miles, M. D., State Zoologist.

Part III. Catalog of the wild phaenogamous and acrogenous plants of Lower Michigan with botanical notes upon the distribution.

*Volume I. Upper Peninsula 1869-1873. Accompanied by an atlas.

Part I. Iron Bearing Rocks (Economic) by T. B. Brooks. 320 pp. 4 views, 20 Pls. and 29 Figs. (a) Historical sketch of discovery and development; (b) Geological sketch of the Upper Peninsula (where to explore); (c) Lithology, mineral composition and classification of rocks; (d) Geology of the Marquette iron region; (e) Menominee iron region; (f) Gogebic and Montreal river iron range; (g) Explorations; (h) Magnetism of rocks and use of the magnetic needle in explorations; (i) Method and cost of mining specular and magnetic ores; (j) Chemical composition and analyses; (k) Appendices: 1. Lithological descriptions of Huronian rocks and ores. 2. Catalog of state collection. 3. Microscopic determination and descriptions. 4. Discovery of iron ores. 5. Magnetic analyses. 6. Synopsis of minings laws of Michigan. 7. Metallurgical qualities, etc., of Lake Superior ores. 8. Structure of banded ores and jasper.

Part II. Copper District by Raphael Pumpelly. 144 pp. 11 atlas plates. (a) Age of copper bearing rocks; (b) Lithology; (c) Paragenesis and derivation of copper and associated minerals; (d) Correlation of rocks; (e) Descriptive cross-sections; (f) General structure and lithology.

Part III. Palaeozoic Rocks of the Upper Peninsula by C. Rominger. (a) Limits and surface configuration; (b) General geology of the bed rock and the surface deposits; (c) The formations, their character, distribution, fossils, minerals and ores, etc.

*Volume II. Upper Peninsula 1869-1873. Appendices to Part I, Volume I.

Iron Bearing Rocks (Economic) by T. B. Brooks. 298 pp., 20 Pls., 21 Figs.

Appendix A: Lithological descriptions of 259 specimens of Huronian and Laurentian rocks by A. A. Julien. B: Catalog of state collection of Huronian rocks and ores; C: Microscopic determinations and descriptions of 78 specimens by C. E. Wright; D: Relating to the discovery of iron ores by United States surveyors; E: Notes on rocks along the shores of Lake Superior near Marquette, from Mss. of Dr. Houghton; F: Iron ore dock at L'Anse; G: Population of the Upper Peninsula in 1870; H: Magnetic analyses and color of powder of Marquette ores by F. B. Jenney; I: Synopsis of mining laws by C. D. Lawton; J: Metallurgical qualities and richness of Lake Superior ores, etc., by H. B. Tuttle; K: Lamination, plication, and faulting of banded ore and jasper (illus.)

*Publication out of print.

C. ROMINGER, State Geologist.

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Part II. The Menominee Iron Region by C. Rominger: Stratigraphy, character and distribution of iron bearing formations and associated rocks.

C. E. WRIGHT AND M. E. WADSWORTH, State Geologists.

See Vol. II and Vol. V, also the reports of the Commissioners of Mineral Statistics and the following entry:

*Report of the State Board of Geological Survey for 1891 and 1892. Also reports of Dr. Carl Rominger for 1881 and 1882; of C. E. Wright for 1885 to 1888, inclusive.

(a) Expenses of Survey from its inception to 1892; (b) Reports of Dr. Carl Rominger for 1881 and 1882, with notes on the iron bearing rocks in vicinity of Gogebic lake, Michigan; (c) of C. E. Wright for years 1885-8, with notes on the geology of the region between Marquette and L'Anse on magnetic belts, and on gas and salt wells in the Lower Peninsula; (d) of M. E. Wadsworth for 1888 to 1892 containing geological notes on the rocks between Iron River and Lake Gogebic and along the shore north of Marquette, on occurrences of gold west of Ishpeming, on granite, on the iron bearing country between the Marquette and the Menominee ranges, on the Marquette district, on the geological column, on gas and oil, salt wells, building stone, clay, slate, etc.; (e) Sketch of the geology of the iron, gold and copper districts by M. E. Wadsworth: 1. Geological formations (a) Upper Peninsula, (b) Lower Peninsula; 2. Azoic (Archean) system: (a) Cascade formation on the oldest sediments or eruptives, (b) Republic formation: conglomerates, quartzites, dolomite, jaspilite and iron ore, (d) Holyoke formation: conglomerates, quartzites, graywackes, granite, diabase, melaphyre, etc.; 3. Chemical deposits of the Azoic; 4. Palaeozoic system: Potsdam sandstone, Eastern sandstone, North Trap range, South Trap range; 5. Veins and copper deposits on Keweenaw Point; 6. Minerals and rocks of Michigan—varieties, analyses, microscopic characteristics, etc.; (f) Extracts from the annual reports of the State Geologist, L. L. Hubbard for 1897-8, containing notes on the geology of Tuscola county, etc.

L. L. HUBBARD, State Geologist.

Volume V. Upper Peninsula 1881-1884; Lower Peninsula 1885-1893.	
Prefatory note by L. L. Hubbard. Bound in heavy green cloth	1.00 .27

Part I. Geological Report on the Upper Peninsula of Michigan, exhibiting progress of work from 1881-1884. Iron and Copper Regions by C. Rominger. 180 pp. 1 map and 2 geological cross sections.

*Publication out of print.

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(a) Introduction relative to the use and meaning of geologic terms and names; (b) Granitic group; (c) Dioritic group; (d) Iron ore group: 1. Marquette region, 2. Menominee, 3. Gogebic, 4. Penokee-Gogebic, Wisconsin, 5. Vermilion range, Minnesota; (e) Arenaceous slate group; (f) Mica schist formation; (g) Keweenaw group.

Part II. Geology of Lower Michigan with reference to Deep Borings. Edited from notes of C. E. Wright by A. C. Lane. 102 pp. 73 Pls. and 1 map. (a) An introduction on the origin of salt, gypsum and petroleum by L. L. Hubbard; (b) General geological considerations and difficulties in correctly interpreting the structure and character of the rock formations from well borings; (c) Geological formations of the Lower Peninsula and their economic products: 1. Descriptions of the various formations, 2. Occurrence of economic products: coal, gypsum, salt, bromine and bromides, mineral waters, oil and gas, and 3. Methods of taking and testing samples from well borings; (d) Well sections and their preparation, and geological sections and their use; (e) Particular descriptions of deep borings; (f) Plates illustrating character, thickness, mineral, and water content, etc., of the rock strata penetrated in the various deep borings; (g) Cross sections showing major and minor structures of the Michigan Basin.

*Volume VI. Upper Peninsula 1893-1897. Bound in heavy green cloth.

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(a) Historical Introduction; (b) Construction of a cross section from the drill records; (c) The succession of rocks; (d): 1. Grain of rocks, 2. Appendix to Chapter IV—Mathematical treatment of cooling problems; (e) Applications of the theory of the grain of rocks to Keweenaw rocks; (f) Petrography; (g) Topography and glacial geology; (h) Stratigraphy; (i) Chemical problems; (j) Diabases intrusive into the Huronian.

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ALFRED C. LANE, State Geologist.

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.50 .12

Part II. Geological Report on Huron county by A. C. Lane. 330 pp. 11 Pls., 12 Figs. and 2 maps in colors. Bound in paper, cloth backs.

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Part III. Geological Report on Sanilac county by C. H. Gordon. 34 pp. 5 Pls., 2 Figs. and 3 maps in colors. Bound in paper, cloth backs.

(a) Topographic features; (b) Stratigraphy, distribution, and structure of the underlying formations: 1. Coldwater shales, 2. Marshall

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sandstone, and 3. Pleistocene deposits; (c) Economic resources: Building stone, sandstones, gritstones (grindstones), shales and clays, soils, water supplies, wells and borings, etc. \$0.15 \$0.05

***Volume VIII. Lower Peninsula—Economic, 1900–1903. Bound in heavy green cloth.**

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(a) Physical and chemical properties; (b) Uses: Fire brick, terra cotta, pottery, Portland cement, mineral paint, road material, and slip clays; (c) Shale bearing formations: 1. Coal measures, 2. Michigan Series, 3. Coldwater, 4. Devonian (Antrim and Traverse formation), 5. Hudson river; (d) Clay deposits; (e) Analyses; (f) Tests.

Part II. Coal in Michigan, its Mode of Occurrence and Quality, by A. C. Lane, 1901. 234 pp. 9 Pls. and 9 Figs. including one colored map
(a) Origin of coal; (b) Occurrence; (c) Analyses and tests; (d) Erosion and disturbance; (e) Exploration and development; (f) Value of coal lands and royalties; (g) Borings for coal arranged by counties. 1.00 .15

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Volume IX. Bound in heavy green cloth, 1904 1.00 .20

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Part II. The Gypsum of Michigan and the Plaster Industry, by G. P. Grimsley, 1903. 248 pp. 29 Pls. Bound in paper.

(a) Introduction: 1. Properties of gypsum, 2. Early history of industry, etc.; (b) Occurrence of gypsum in other countries; (c) In the United States; (d) History of the gypsum industry; (e) Geology and topography of the Michigan Series,—the gypsum bearing formation; (f) Gypsum deposits at St. Ignace; (g) Study of well borings; (h) Michigan mines and mills; (i) Technology and chemistry of gypsum and gypsum plasters; (j) Testing of gypsum wall plasters; (k) Origin of gypsum; (l) Uses of gypsum; (m) Appendices: Statistics and bibliography.60 .15

***Annual Report for 1901. 304 pp. 15 Pls. and 7 Figs.**

(a) Notes on the progress of work in Tuscola, Saginaw, Bay, Alpena, Kent, Washtenaw, and Muskegon counties; (b) Preliminary report on Arenac county, by W. M. Gregorv: 1. Introductory notes, 2. Limestone, 3. Gypsum, 4. Coal, 5. Water supply, water power, and flowing wells, 6. Clay and shales, 7. Agricultural resources; (c) Report on Alcona county: Surface geology by Frank Leverett, subsurface geology by A. C. Lane: 1. Climate, 2. Glacial deposits, 3. Lake history, 4. Economic resources: soils, marl, clay, water power, wells and borings, oil and gas possibilities, salt, water and mineral water, peat, etc.; (d) Distribution of the Plant Societies of Kent county, by B. E. Livingston; (e) Preliminary report on the surface geology of Lapeer county, by F. B. Taylor; (f) Economic geology of Michigan: 1. Relation to the industrial world. 2. Raw materials: water power, wood, oil and gas, iron, copper, sandstone, limestone, salt, precious metals, etc.; (g) Limestones: 1. Distribution, character and analyses of various limestone beds in the state, 2. Development of deposits; (h) Stratigraphy of the Traverse group of Michigan, by A. W. Grabau. 49 pp. Also contains valuable data concerning water supplies, limestone, shale and clay deposits in the regions of Little Traverse Bay and of Alpena (Thunder Bay to Presque Isle); (i) Deep wells and borings for Oil and Gas in Michigan: 1. Southwestern district, 2. Southeastern, 3. Port Huron, 4. Saginaw, 5. Northern part of state, 6. Lake Michigan shore; (j) Salt; (k) Meteorites; (l) Geothermal gradient; (m) Appendix: 1. The Port Huron oil field, and 2. Wave cutting on west shore of Lake Huron, Sanilac county, by C. H. Gordon.

***Annual Report for 1902. 26 pp. 1 geological map. Published in the Michigan Miner, Saginaw, January, 1903.**

(a) Preliminary report on the gypsum deposits of Michigan by G. P.

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Grimsley; (b) Field and laboratory tests of Bay county waters; (c) Notes on economic products: moulding sand, peat, limestone, road metal iron bearing rocks, water power, wells and deep borings, etc.

***Annual report for 1903. 342 pp. 6 Pls. (soil, vegetation, and geologic maps) 10 Figs.**

(a) Relation of soils to natural vegetation in Roscommon and Crawford counties, by B. E. Livingston, 30 pp.; (b) Report on progress made in the Porcupine mountains; (c) Water supply of Lower Michigan, W. F. Cooper, 63 pp.: 1. Artesian well areas, 2. Springs and non-flowing wells, 3. Analyses of springs, 4. Topography and water power, 5. Water supply of Lenawee, Hillsdale, Branch, St. Joseph, and Cass counties, 6. Analyses of Lower Peninsula waters; (d) Waters of Upper Peninsula of Michigan, by A. C. Lane, 67 pp.: 1. Analyses of lake, river, mine and well waters, 2. Well records and deep borings, 3. Water bearing strata; (e) Limestone and limestone areas, analyses, etc., 25 pp.; (f) Building and road materials, 12 pp.: 1. Stone, 2. Brick, and 3. Cement; (g) Analyses; (h) Transmission of heat into the earth, by A. C. Lane, 43 pp.: 1. Mathematical calculation, 2. Grain of rock; (i) Theory of copper deposition, by A. C. Lane, 12 pp. 2 Figs.; (j) Tamaraack mine cross section and the Keweenaw lodes, 19 pp.; (k) Deep borings for oil and gas, 21 pp.; (l) Peat; (m) Topographical survey; (n) Recent shore forms, etc.

***Annual Report for 1904. 182 pp. 17 Pls., 5 Figs. 3 Maps.**

(a) Failure of wells along the Lower Huron river, Michigan, in 1904, by Myron L. Fuller, 29 pp.: 1. Water supplies of the Lower Huron river district, 2. Decline of water supplies of the wells, 3. Necessity of laws for regulating deep or artesian wells; (b) Geological reconnaissance along the north shore of lakes Huron and Michigan, by I. C. Russell, 122 pp. 15 Pls. 2 Figs.: 1. Introductory statement, 2. Outline of geological history, 3. Hardrock geology,—the formations, 4. Surface geology, 5. Glacial deposits, 6. Fluvio-glacial deposits, 7. Beaches of former lakes, 8. Glacial lakes, 9. Topographic features of lake shores, 10. Lake and swamp deposits, sand dunes, and soils, 11. Recent changes of shore line; (c) Executive report, containing notes on substitutes for wood, clays and shales, sand-lime brick, cement, peat, coal, gold and oil; (d) Report of special committee for the Lake Superior region: 1. Successions and relations of formations obtaining in the various districts of United States and Canada, 2. The districts—Marquette, Penokee-Gogebic, Mesabi, Vermilion, Rainy Lake, Thunder Bay, Northern Lake Huron, etc., 3. Correlations, 4. The Laurentian problem, 5. Grain of Logan Sills; (e) Lake Superior gold mining; (f) Black River work; (g) Wells and borings.

***Annual Report for 1905. 638 pp.**

Includes the following parts bound separately:

- *(a) An ecological survey in Northern Michigan by Chas. C. Adams.**
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Part I. The Porcupine Mountains; History, topography, and geology; Biota considered by field stations; Summary, interpretations, and conclusions.

Part II. Isle Royale; General geography; Biota considered by field stations; Summary and conclusions. 2. The ecological distribution of birds in the Porcupine Mountains, by Otto McCreary:

Part I. The Lake Superior or slope of the first mountain ridge.

Part II. Carp river valley.

Part III. Hardwood forest south of Carp river.

Part IV. Little Carp river valley.

Part V. Summary.

3. Ecological relations of the orthoptera in the Porcupine Mountains.

4. Notes on the plants of the Porcupine Mountains and Isle Royale.

5. Annotated list of molluscs of the Porcupines and Isle Royale, by Bryant Walker.

6. Spiders and insects from the Porcupines.

7. Cold blooded vertebrates of the Porcupines and Isle Royale.

8. Annotated list of the birds of the Porcupine Mountains and Isle Royale.

9. Notes on the mammals of the Porcupines and Isle Royale.

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R. C. ALLEN, State Geologist.

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 (d) Preliminary list of the sites of aboriginal remains, by H. I. Smith, American Museum of Natural History, New York.....

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(a) Popular description of major geological structures of Lake Superior Basin, the stratigraphy, etc.: 1. The Keweenaw fault and other faults, 2. The general character and succession of the beds, 3. Sources of copper, 4. Agents of metamorphism, 5. Resultant minerals, 6. Shear zones and shoots, 7. Surface geology, 8. Distribution of float copper; (b) Nomenclature and chemical relations of the Keweenaw rocks; (c) Microscopic petrography—the minerals and textures; (d) The grain of igneous rocks; (e) Detailed stratigraphy as shown by the mines and outcrops.

Volume II.

(f) Temperature of the copper mines; (g) Mine waters; (h) Copper formation; (i) Comparison with similar deposits; (j) The development of the copper mines and their geological relations, by A. H. Meuche; (k) Appendix: Recent developments, geological questions, and bibliography.2.65 .35

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(j) Directory of the mineral producers of Michigan.

(k) Miscellaneous statistical tables—pottery, mineral waters, clay, sandstone, lime, limestone, sand and gravel, sand-lime brick, brick and tile, summary of mineral products.

(l) Appendix—Production and value of mineral products of Michigan for 1911.

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(d) Lake features and history: 1. Introductory statement, 2. Lake Chicago, 3. Lake Maumee, 4. First Lake Saginaw, 5. Lake Arkona, 6. Later Lake Saginaw, 7. Lake Whittlesey, 8. Lake Warren, 9. Lake Wayne, 10. Lake Elkton, 11. Beginnings of Lake Erie and Lake St. Clair, 12. Lake Algonquin, 13. Nipissing Great Lakes.
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Geological Report on Arenac County, by W. M. Gregory. 145 pp. 7 Pls. 18 Figs.

- (a) Historical and geographical introduction; (b) Previous geological work; (c) Climate; (d) The geological column; (e) Geology of the palaeozoic formations; (f) Pleistocene or glacial geology; (g) Water resources: Pt. I. Hydrology, Pt. II. Hydrography; (h) Altitudes or elevations; (i) The soil and soil products; (j) Economic resources and raw materials: sand and gravel, the sand soil products, the jack pine flora, clay, gypsum, limestone, coal, water resources, and the soils.

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Publication 12, Geological Series 9. 1911.

Geological Report on Wayne County by W. H. Sherzer. 388 pp. 32 Pls. 22 Figs.

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Publication 13, Geological Series 10. 1912.

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- (a) Michigan copper industry in 1912, by R. E. Hore, Michigan College of Mines. 81 pp. 8 Pls. 1. General trade conditions,—dividends paid by companies, scarcity of labor, increased construction and development

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work, diamond drill exploration, employer's liability and workmen's compensation act. 2. The copper industry by companies. 3. Statistical tables.

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(c) Sand and gravel. 1. Production and value. 2. New directory. 3. Testing of sand and gravel for concrete material.

(d) Preliminary statement on limestone. 1. Previous reports on limestone. 2. Present limestone reserves of the state. 3. Field work on the limestone deposits of the state in 1913.

(e) Statistical tables for 1912 and prior years. 1. Iron ore. 2. Pig iron. 3. Portland cement. 4. Salt. 5. Brick and tile. 6. Coal. 7. Limestone. 8. Sand and gravel. 9. Gypsum. 10. Silver. 11. Sand lime brick. 12. Pottery. 13. Mineral water. 14. Trap rock. 15. Sandstone. 16. Clay. 17. Natural gas. 18. Summary table of production and value of mineral products for 1912.

(f) Directory of mineral producers in Michigan for 1912. \$0.60 \$0 10

Publication 14, Geological Series 11. 1912.

The Occurrence of Oil and Gas in Michigan, by R. A. Smith, 281 pp., 3 Pls., 19 Figs.

(a) Letter transmittal. 1. Warning against fraudulent schemes for exploration for oil and gas and against so-called "locators" and "oil smelters." 2. "Community projects." 3. Encouragement of legitimate exploration.

(b) Introduction. 1. Object and plan of the report. 2. Acknowledgments.

(c) The Michigan Basin. 1. Major structure. 2. Minor structure. 3. The geological section and formations described.

(d) Geological factors controlling the occurrence of oil and gas. 1. The anticlinal theory. 2. Forms of oil and gas reservoirs. 3. Generalizations concerning the application of the anticlinal theory. 4. Rock pressure and its causes. 5. Surface indications of oil and gas.

(e) The Port Huron oil field. 1. Early history and development. 2. Geological conditions in western Ontario. 3. The Petrolia oil field. 4. Explorations and records of wells in western Ontario. 5. Explorations and records of wells in the Port Huron oil field. 6. The Port Huron anticline. 8. The oil horizons. 9. Early salt wells in Huron and Sanilac counties.

(f) The southeastern district. 1. Rock structures. 2. Relation of surface signs to oil and gas horizons. 3. Explorations and records of wells in Monroe, Lenawee, Hillsdale and Wayne counties. 4. Local structures Wyandotte and Stony Island anticlines. 5. Explorations and records of wells in Washtenaw, Oakland, Macomb and St. Clair counties. 6. Local structures in Macomb and eastern St. Clair counties. 7. Conclusions.

(g) The Saginaw oil field. 1. The Saginaw Valley Development Company. 2. The Saginaw anticline. 3. The explorations. 4. The oil horizons. 5. Favorable area for exploration. 6. Character and composition of the oils.

(h) Central Michigan. 1. Geographic and geologic relations. 2. Explorations and records of wells in Bay, Saginaw, Genesee, Midland, Gratiot, Isabella, Gladwin, Mecosta, Kent, Ionia, Barry, Eaton, Ingham, Jackson and Calhoun counties. 3. Local geology in Livingston, Shiawassee and Clinton counties. 4. Explorations and records of wells.

(i) The southwestern district. 1. Occurrence of oil in the vicinity of Allegan. 2. Character of the formations and local structures. 3. Explorations and records of wells at Allegan. 4. The local structures in Berrien, Cass, St. Joseph and Kalamazoo counties—the Berrien Springs syncline and the anticline near Niles. 5. The oil horizons. 6. Explorations and records of wells.

(j) Western Michigan. 1. Explorations and records of wells in Muskegon, Mason and Manistee counties. 2. The Manistee anticline. 3. Occurrence of gas in the vicinity of Portage Lake, Manistee county, the Onokama gas well.

(k) Northern Lower Michigan. 1. Relation of surface deposits to exploration. 2. Bed rock geology. 3. Little Traverse bay or Khagahew Point anticline. 4. Explorations and records of wells in Benzie, Emmet, Charlevoix, Wexford, Cheboygan, Crawford, Roscommon, Presque Isle and Alpena counties. 5. Local structures in the northeastern part of the Southern Peninsula. 6. Relation of rock formations to surface signs in Alcona county. 7. Explorations and records of wells. 8. Conclusions. 9. Explorations and records of wells in Iosco, Ogemaw and Arenac counties.

(l) Northern Peninsula. 1. The Paleozoic area. 2. The Wisconsin section. 3. Explorations and records of wells in eastern Wisconsin and Menominee and Delta counties. 4. Occurrence of oil and asphalt in the

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Trenton limestone. 5. Explorations and records of wells in Schoolcraft, Mackinac and Chippewa counties and on Manitoulin Island, Ontario.

(m) The regulation of drilling and care of deep borings. 1. Flooding of oil and gas sands by water from improperly cased or abandoned and unplugged wells. 2. Menace of oil and gas wells to coal mining operations and to valuable brines, mineral and potable waters. 3. Necessity for the regulation of the drilling and care of borings. 4. Inadequacy of present laws. 5. Difficulties of framing adequate remedial and preventative measures. 6. Conference of interested parties called by the U. S. Bureau of Mines. 7. The proposed regulations.

(n) Bituminous or oil shales. 1. Oil shale industry in the United States in 1860. 2. History of the oil shale industry in Scotland and other countries. 3. Investigation of the oil shale resources of eastern Canada by the Department of Mines of Canada in 1910. 4. By-products of the oil shale industry. 5. Recent investigation of the oil shales of Colorado and Utah by the U. S. Geological Survey. 6. Oil shales of Michigan. 7. Oil shales and oil coals as future resources of oil.....

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Publication 15, Geological Series 12. 1913.

Brine and Salt Deposits of Michigan, by Chas. W. Cook,
181 pp., 15 Pls., 47 Figs.

(a) Introduction. 1. Distribution. 2. Physical properties of salt. 3. Previous work.

(b) Historical account. 1. Governmental development. 2. Private initiative.

(c) Theories of the origin of salt deposits. 1. Volcanic. 2. Evaporation—the Ohsenius and Walther's. 3. Dome.

(d) Brine theories. 1. Original sea water. 2. Solution.

(e) Geology of the brine and rock salt formations and the character and origin of the brines and rock salt. 1. Parma. 2. Marshall. 3. Berea Grit. 4. Dundee. 5. Upper Monroe or Detroit River Series. 6. Salina. 7. Summary.

(f) Salt manufacture. 1. Wells—well drilling machinery, boring and pumping methods. 2. Preliminary treatment of brines. 3. Methods of evaporation—direct heat and steam.

(g) Character, production and value of salt in Michigan.

(h) Geology, production and operating companies by counties. 1. Saginaw. 2. Bay. 3. Huron. 4. Macomb. 5. Iosco. 6. Midland. 7. Gratiot. 8. Manistee. 9. St. Clair. 10. Mason. 11. Wayne. 12. Isabella.

(i) Appendix A. Bibliography of Michigan salt deposits.

(j) Appendix B. The salt inspection law..... .60 .10

Publication 16, Geological Series 13. 1913.

Mineral Resources of Michigan for 1913 and prior years.

(a) The Michigan Copper Industry in 1913 by R. E. Hore. 1. General conditions. 2. Profits and losses. 3. Cost of mining. 4. Wages paid. 5. Exploration. 6. New construction. 7. Earnings and dividends. 8. Summary of mining operations for 1913 by mines. 9. Statistical tables of production and value of copper. 10. Summaries of financial statements of mining companies.

(b) The Iron Ore Reserves of Michigan by R. C. Allen. 1. A brief description of the iron bearing formations—relation to other formations; thickness, deformation and alteration; the formation of the ore bodies; depth to which iron ore occurs. 2. Importance of the iron mining industry in Michigan. 3. Permanency of the industry—mining at deep levels, development of unexplored lands, opening of abandoned mines, utilization of low grade ores, and recent estimates of Michigan iron ore reserves. 4. Royalty and ownership. 5. Value of iron ore in Michigan in 1913. 6. Statistical tables on production and value of iron ore, on iron ore reserves, mining costs and appraised value of mines, prices of ore, freight rates, iron ore shipments by mines, ranges and counties. 7. List of active iron mines with location, ownership, depth of bottom levels and number of men employed.

(c) Non-metallic Minerals by R. A. Smith. 1. Limestone—general business conditions, description of the limestone formations, location and character of the principal deposits, statistical tables of production and value. 2. Lime—general business conditions and statistical tables. 3. Sandstone—general character of the sandstones of Michigan, causes of the decline of the sandstone industry, statistical tables. 4. Shale—Uses of shale and location of shale resources. 5. Trap rock—location of the trap rock deposits, growth of the industry, statistical tables. 6. Grindstones and scythestones—location of the grit or grindstone quarries and method of quarrying. 7. The Michigan Slate Industry by O. R. Hamilton—location and description of the black slate deposits of Baraga county, attempted developments, former production and value of slate. 8. Sand and gravel—growth of the industry, difficulty of obtaining complete statistical data, the use of sand and gravel for concrete aggregates, statistical tables. 9.

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Salt—general trade conditions, seats of the industry, extent of the salt beds, statistical tables. 10. Cement—growth of the industry in Michigan, increased prices in 1912-1913, future outlook, statistical tables. 11. Gypsum—growth of the industry in Michigan, present developments, extent and distribution of the gypsum resources, statistical tables. 12. Clay—character and uses of the clays of Michigan, statistical tables. 13. Pottery—trade conditions and statistical tables. 14. Brick and tile—general trade conditions, character of the brick and tile products in Michigan, statistical tables. 15. Sandlime brick—growth and importance of the industry in Michigan, location of the plants, statistical tables. 16. Mineral waters—decline and causes of the mineral water industry in Michigan, statistical tables. 17. Natural gas—"shale" and surface gas wells, statistical tables. 18. Petroleum. 19. Graphite—location of the graphite deposits. 20. Quartz. 21. Mineral paints—metallic paint from iron ore. 22. Coal—statistical tables. 23. Summary of the production and value of the mineral products of Michigan for 1913. 24. Directory of mineral producers of Michigan for 1913.

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